GenRad

Instruction Manual

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WARNING - SHOCK HAZARD
SEE SECTION 5

GR 2220
Bug Hound

Form 2220-0100-B

Symbol ⚠ on equipment signified that the instruction manual contains information about the unit that personnel should be aware of to prevent possible inadvertent damage to it. Refer to Section 5.

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Concord, Massachusetts, U.S.A. 01742
April, 1980

Specifications

Microvoltmeter

Accuracy: ±(20% of full scale + 10μV)
Ranges: 50-0-50μV and 500-0-500μV
Input impedance greater than 100 ohms
Differential protection between probes ±15 volts

Dc Current Source

Compliance: 1V dc max., open circuit
Output current: 10mA ±20% into short circuit

Current-Sensing Probe

Source drive signal: 600kHz ±20%, 1V Peak max. into open circuit
20mA p-p square wave into short circuit
Detector probe: sensitive to source if probe held within 1/8" of copper track

Connectivity Test

Detects resistance less than 68 ohms ±10%

Power Requirements

100 to 175 or 200 to 250V
50 or 60Hz
Power consumption less than 5 watts

Mechanical

Dimensions: 8.5" W x 3.12" H x 12.25" D
21.6cm W x 8.4cm H x 31.1cm D
Weight: 2.5 kg (5.6 lb) net.

Warranty

GenRad

WARRANTY

We warrant that this product is free from defects in material and workmanship and, when properly used, will perform in accordance with applicable GenRad specifications. If within one year after original shipment it is found not to meet this standard, it will be repaired or, at the option of GenRad, replaced at no charge when returned to a GenRad service facility. Changes in the product not approved by GenRad shall void this warranty. GenRad shall not be liable for any indirect, special, or consequential damages, even if notice has been given of the possibility of such damages.

THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

GenRad policy is to maintain product repair capability for a period of ten years after original shipment and to make this capability available at the then prevailing schedule of charges.

Introduction–Section 1

1.1 INTRODUCTION 1-1
1.2 GENERAL DESCRIPTION 1-1

1.1 INTRODUCTION.

The GenRad 2220 Bug Hound is a small bench-top instrument designed to aid in the determination of the physical location of printed-circuit board short and open circuits, and certain types of component faults. Several techniques can be used to achieve this end, depending on the nature of the fault. The Bug Hound is most compatible with, and a logical extension to, digital logic-circuit test systems. Frequently, a shorted node can be electrically resolved using a test system designed for that purpose, but the physical location is not readily found (as with hair-line etch-circuit board shorts or opens). Also, as is the case with many of the higher-density and multi-layer boards used today, even if the faulty node is known, it can be very difficult to locate the physical fault by visual inspection. Close visual tracing of a track is not a necessity with the Bug Hound. The 2220 design is such that the electrical path of a shorted track can be followed and "sniffed" out by audio and visual means. A speaker emitting 1 of 2 audio tones and 2 LED diodes indicate that the probe is in close proximity to the track. If no indications are emitted, the probe is not near the track of interest. In addition, no power to the board under test is required.

The Bug Hound is intended for use after a board fault has been diagnosed by a logic-circuit test system. The utility of the message defining the fault depends on the sophistication of the system. GenRad manufactures high-resolution logic-circuit test systems that can utilize the GR Diagnostic Resolution Module (DRM) with the Fault Isolation Nodal Diagnostic Software (FINDS) package. With DRM/FINDS, it is possible to resolve the fault from the nodal level down to a specific fault type or a bad IC pin. Having found the faulty node, an investigation using DRM/FINDS is made to resolve a fault to one of the following fault types:

1. Shorts/opens between an IC pin and power or ground.
2. Shorts/opens between adjacent IC pins.
3. Faulty IC's.
4. Shorts between tracks on a board.

Even without the optional DRM/FINDS package, GR test systems generally provide more information than most other testers. For example, along with the node definition the comment NODE LOW BUT ACTIVE may be added instead of just BAD NODE AT XXX. This comment indicates that the node is not shorted to ground, but rather to another node.

1.2 GENERAL DESCRIPTION.

1.2.1 General.

The 2220 has three basic modes of operation; a signal trace mode, a connectivity mode, and a microvoltmeter mode. The unit is self-contained and supplied complete as a bench-top instrument.

1.2.2 Signal-Trace Mode.

The principal application for the signal-trace mode is in locating a short between 2 nodes when both nodes are known. When the Bug Hound is operating in this mode, a 600 kHz trace-current is connected between the two shorted nodes. Two clip leads are attached, at any point on each node. The current-tracing probe is then utilized to track down the physical fault location by visual (LED indicators) and audio (speaker-tone) means.

1.2.3 Connectivity Mode.

The signal-trace mode can only be used when two or more shorted nodes are known. If a diagnostic message identifies one node that is shorted to another unidentified node, the connectivity mode is used to physically locate the second node. Two probes are used; one is placed on any point of the known node, while the other is swept across the etch track. When an audible tone is heard, the other node (or another point of the known node) is located. Probing is continued until the second unidentified node is found. The actual short is then located by either visual means, or by using the signal-trace mode.

This mode is also used to locate open circuits.

1.2.4 Microvoltmeter.

The microvoltmeter has a zero-center meter with full-scale sensitivities of either +/—50 or +/—500 uVdc. As with the signal-trace mode, the microvoltmeter mode also requires that two shorted nodes be identified previously. A 10 ma dc current source is then connected between the nodes to provide a potential gradient along the tracks carrying this current. This very small IR drop is sensed by the microvoltmeter as an increasing or decreasing potential as one probe is moved along the track. The moving probe is visually followed to the point where the short is located.

The microvoltmeter is especially well-suited for finding shorts between power bus and ground tracks. In this situation, the signal-trace mode is ineffective because the power-bus bypass capacitors look like short circuits to the 600 kHz trace current.

The microvoltmeter can also be used in lieu of the signal-trace mode as an alternate means of finding board shorts.

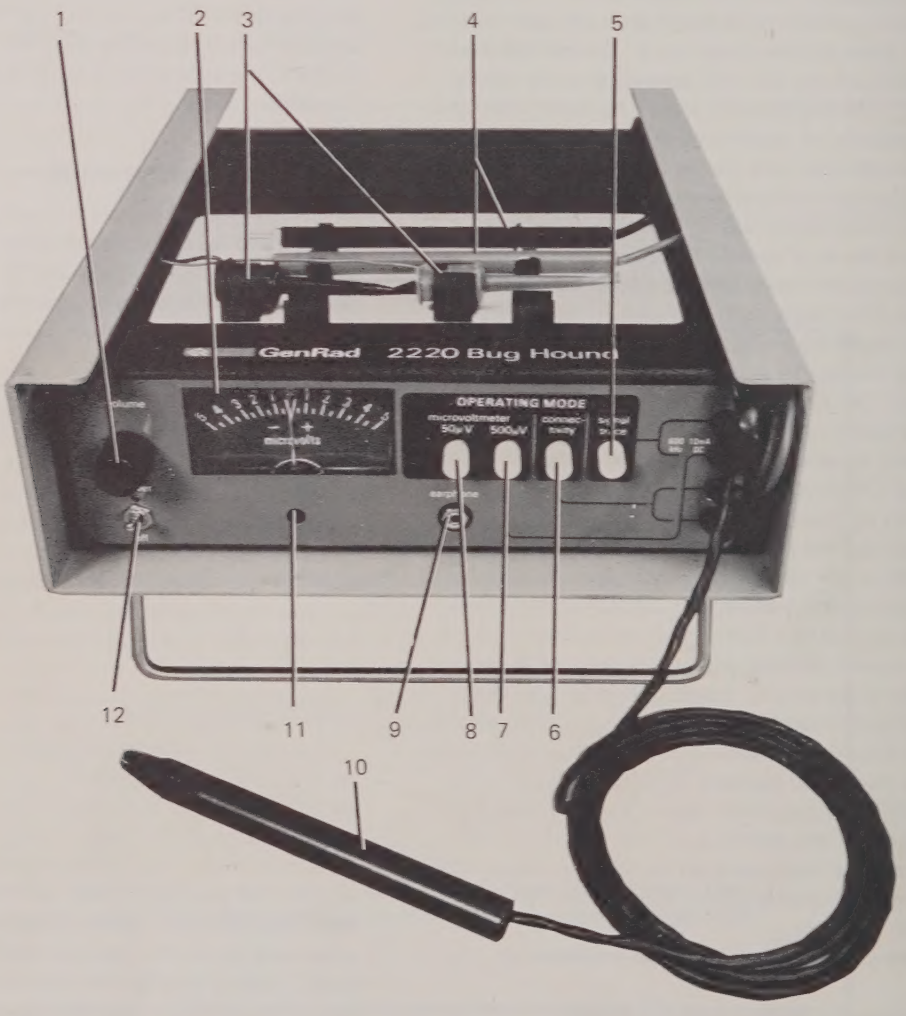

Figure 1-1. Front panel controls and indicators.

Table 1-1

CONTROLS, INDICATORS, AND CONNECTORS

Figure 1-1 Ref. No.	Name	Description	Function
1	volume	Knob control. Rotary cw adj.	Adjusts audio level of speaker tone in Signal-trace and Connectivity modes.
2	meter	Microvoltmeter. Minus-zero-plus.	Indicates reading in microvolts of either 50 or 500 uV full scale (see Fig. 1-1 items 7 and 8).
3	signal clips	Red and black push-type clips.	In Signal-trace mode these clips provide a 600 kHz trace current for the probe (Fig. 1-1, item 10) to follow; in the microvoltmeter mode a 10 ma dc signal is clipped to two track points and the test probes (Fig. 1-1, item 4) are used to detect the signal.
4	test probes	Red and black probes.	In Connectivity mode these probes are used to find a point on an unknown node. In the microvoltmeter mode these probes are used as the meter input probes.
5	signal-trace	1 of 4 Operating Mode interlocking pushbuttons	Sets instrument to Signal-trace mode activating the current-trace probe (Fig. 1-1, item 10) and producing a 600 kHz signal across the clips (Fig. 1-1 item 3).
6	connectivity	1 of 4 Operating Mode interlocking pushbuttons	Sets instrument to Connectivity mode. The probes (Fig. 1-1 item 4) are used to probe for two points with a resistance <68 ohms.
7	microvoltmeter 500 uV	1 of 4 Operating Mode interlocking	Sets instrument to Microvoltmeter mode with a full-scale reading of +/—500.
8	microvoltmeter 50 uV	1 of 4 Operating Mode interlocking pushbuttons	Sets instrument to Microvoltmeter mode with a full-scale reading of +/—50.
9	earphone	Earphone jack.	Listen to Signal-trace tones or Connectivity mode tone instead of speaker, in noisy environments or without disturbing others.
10	current-trace probe	Probe containing tuned circuit.	In Signal-trace mode this probe enables the 600 kHz stimulus to be tracked.
11	meter set	Microvoltmeter adjust screw.	Mechanical zero-adjust of microvoltmeter.
12	off-on	Toggle-switch.	Turns instrument power on and off.

Table 1-2

REAR PANEL CONTROLS, INDICATORS, AND CONNECTORS

Name	Description	Function
Power Connector (labeled 50-60 Hz).	Safety recessed 3-wire plug.	Ac power input. Use with appropriate power cord such as GR 4200-9625 or equiv.
Fuse (labeled 0.1 A SLOW BLOW)	Fuse in extraction post holder.	Short circuit protection. Use Bussman type 250V 0.1 A or equiv. rating.
Line Voltage Switch	Slide switch. Horiz motion: left pos, 100-125V; right pos, 200-250V.	Adjusts power supply for the appropriate input range.

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Installation–Section 2

2.1 UNPACKING AND INSPECTION 2-1
2.2 DIMENSIONS. 2-1
2.3 TILTING 2-1
2.4 POWER-LINE CONNECTION 2-1

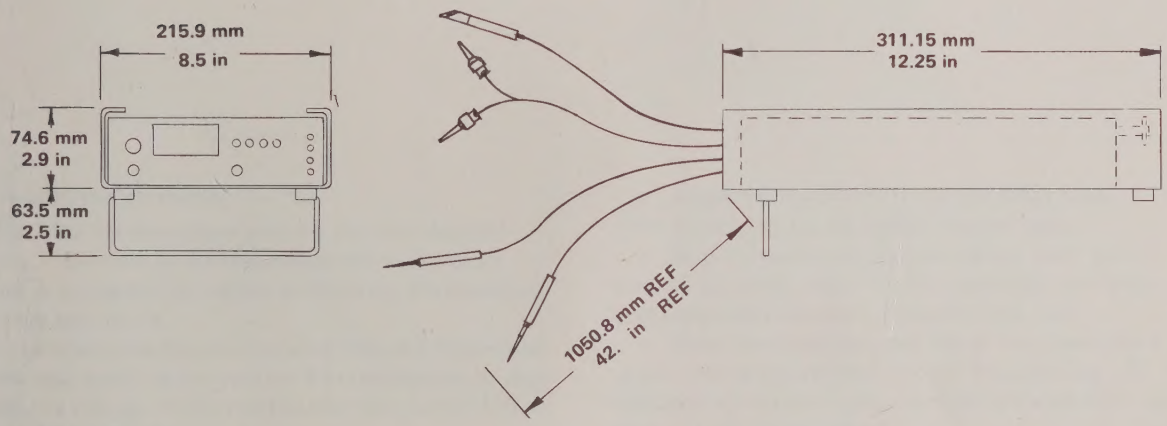

Figure 2-1. 2220 Dimensions.

2.1 UNPACKING AND INSPECTION.

If the shipping carton is damaged, ask that the carrier's agent be present when the instrument is unpacked. Inspect the instrument for damage (scratches, dents, broken parts, etc.). If the instrument is damaged or fails to meet specifications, notify the carrier and the nearest GenRad field office. (See list at the back of this manual). Retain the shipping carton and the padding material for the carrier's inspection.

2.2 DIMENSIONS. Figure 2-1.

The instrument is supplied in a cabinet with resilient feet for placement on a table. The overall dimensions are given in the figure.

2.3 TILTING.

The unit can be tilted back for easier panel viewing. Pull the central part of the bail, which is pivoted at the front feet, down and forward. Let the bail support the front of the instrument. To return the bail to its storage position, push it back and up against the bottom of the cabinet.

2.4 POWER-LINE CONNECTION.

The power transformer primary windings can be switched, by means of the line-voltage switch on the rear panel, to accommodate line voltages in either of two ranges, as labeled, at a frequency of 50 to 60 Hz, ac. Using a small screwdriver, set this switch to match the normal voltage of your power line.

Connect the 3-wire power cable (P/N 4200-9625) to the line and to the power connector on the rear panel. The instrument is fitted with a recessed 3-wire power receptacle. The contacts are recessed to eliminate the possibility of electrical shock whenever the power cord is being unplugged from the instrument. In addition, the center ground pin is longer, which means that it mates first and disconnects last, ensuring user protection. The connector

is rated for 250 V at 15 A. It meets the requirements of Underwriter's Laboratories in the U.S. and the Canadian Standards Association. The receptacle accepts power cords fitted with Belden type PH-386 connector.

The associated power cord for use with that receptacle is GR part no. 4200-9625. It is a 210-cm (7-ft.), 3-wire, 18-gauge cable with connector bodies molded integrally with the jacket. The connector at the power-line end is a stackable hammerhead design that conforms to the "Standard for Grounding Type Attachment Plug Caps and Receptacles", ANSI C73.11-1966. (Specifies 125 V, 15 A.) If the fuse must be replaced, be sure to use a "slow blow" fuse of the current and voltage ratings shown on the rear panel, regardless of the line voltage.

Operation–Section 3

3.1 BASIC PROCEDURE 3-1
3.2 SIGNAL TRACE 3-1
3.3 CONNECTIVITY 3-2
3.4 MICROVOLTMETER 3-2

3.1 BASIC PROCEDURE.

For initial familiarization perform the following procedure. Then refer to the application information contained in this section for details on obtaining the maximum use from each mode.

a. Before connecting the line cord, slide the line-voltage switch (rear panel) to the position that corresponds to your power-line voltage. Power must be nominally either 120 or 220 V (50 to 60 Hz).

If the fuse must be replaced, be sure to use a "slow blow" fuse of the rating shown on the rear panel.

b. Push the interlocking OPERATING MODE pushbutton switch to the desired mode; press either Signal Trace, Connectivity, or 50 uV (Microvoltmeter).

c. Set the power On/Off switch to On.

d. Connect the earphone to the front panel earphone jack if desired.

e. Proceed depending on the mode selected to the appropriate paragraph as follows:

Signal Trace . . . . . para. 3.2
Connectivity . . . . . para. 3.3
Microvoltmeter . . . . . para. 3.4

3.2 SIGNAL TRACE.

The signal trace mode utilizes the current-trace probe and two clip leads for injecting a 600 kHz trace signal. Typically, the 600 kHz signal is clipped across two nodes that have been diagnosed by a test system as being shorted together. One of the nodes can be a ground bus. Perform the following steps:

a. Press the OPERATING MODE Signal-trace pushbutton switch.

b. Unclip the current-trace probe and red and black signal clips from the probe tray.

c. Attach the signal clips to the identified nodes. (Either signal clip can be clipped to either node.)

d. With the current-trace probe (largest black probe) in hand, start from one of the clips with the probe nose held within approximately 1/8 inch of the track.

e. Move the probe from one side of the clipped track to the other using a zig-zag motion. Note that the LED indicators alternately flash on-and-off as the probe is moved from one side to the other.

f. As the probe is being swept from one side of the track to the other, adjust the front-panel volume control cw for an audible tone of the desired level.

g. Next, proceed along the track following it with the probe. If, as the probe is moved down the track the LED indicators do not flash on and off, and the audio tones stop, back up the probe to the point where the indicators are active again. Investigate the reason for the stoppage. Either the node branches at this point, or the physical fault has been encountered.

Example

Figure 3-1 illustrates the signal trace mode. This example assumes that a test system diagnosis has stated that 2 nodes U1-13 and U3-12 are shorted together. The red and black signal clips are placed on these two IC pins as shown (either clip to either point). The path of the 600 kHz ac signal is illustrated by the dotted arrow. Note that it passes through the short. The current-trace probe is then moved along the track starting from one of the identified pins (U1-13). As the probe is moved to point A, the signal is lost. The probe is backed up and moved through a plated-through-hole. The signal is lost at point B on the track located on the other side of the board. As the probe is zig-zagged back toward the hole, the signal re-appears and the short is observed.

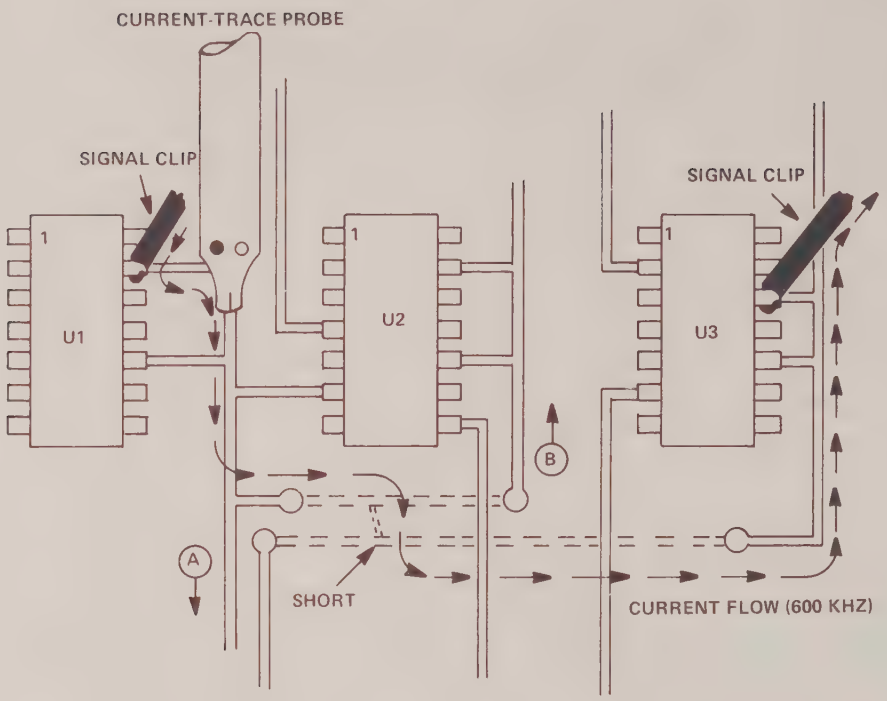

Figure 3-1. Signal trace mode.

3.3 CONNECTIVITY.

The connectivity mode is used in instances where a test system diagnosis identifies only one node. The other node must then be found manually.

Perform the following steps:

a. Push the OPERATING MODE Connectivity pushbutton switch.

b. Unclip the red and black probes (not the signal clips) from the probe tray.

c. Touch the 2 probe tips together and an audible tone is heard as the front-panel VOLUME control is adjusted. Set for desired level.

d. Place one of the probe tips on the identified node, then slowly and lightly sweep the board etch with the other probe until the tone in Step c. is heard. This indicates a path of less than 68 ohms.

e. The tone indicates that either a point on the same node has been located, or an unidentified node has just been found. With both nodes identified, the signal trace mode is used to resolve the fault.

Figure 3-2 illustrates the use of the Connectivity mode. Note that if one probe is placed on U1-3 the tone is heard if the other probe tip contacts either U2-3, U2-5, U2-2 or U3-2. Only the latter two points are on the other node.

3.4 MICROVOLTMETER.

3.4.1 General.

The microvoltmeter uses a 10 mA dc current source as a stimulus along a path between 2 identified nodes. The microvoltmeter indicates both the polarity and the amplitude of even a few microvolts drop along the path through which the current is forced. There are two ranges; 50 and 500 uV. Normally, the 50 uV range is used as described below. The 500 uV range is useful whenever the potential gradient along a track is large because of a narrow track width.

Perform the following general steps to use the microvoltmeter, and then refer to the detailed techniques for use depending on the type of application.

a. Press the OPERATING MODE 50 uV pushbutton switch.

b. Unclip the black and red signal clips and the red and black probes from the probe tray.

NOTE

The following procedures are intended for use with an unenergized board. To use the microvoltmeter on an energized board refer to para. 3.4.3.

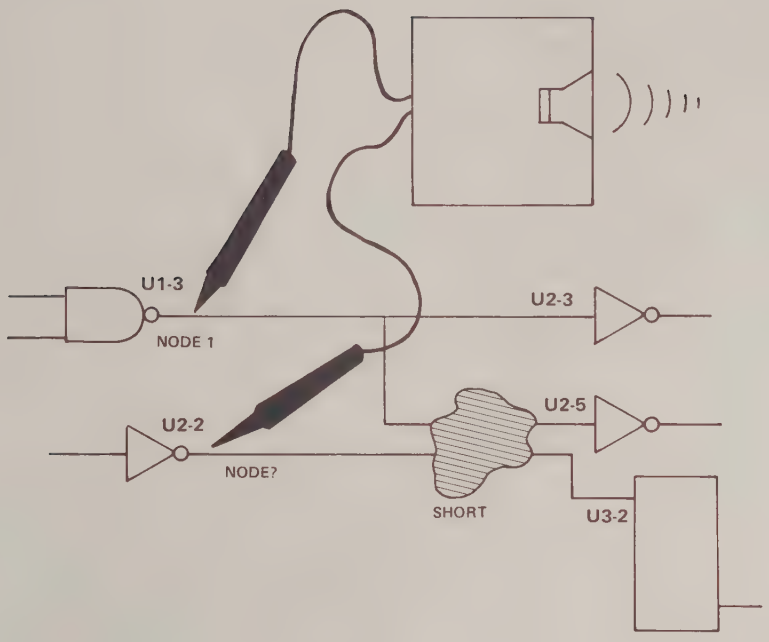

Figure 3-2. Connectivity mode.

c. Place either signal clip onto one of the nodes; place the other clip at a point on the other node.

d. Place and hold either probe at one of the clips, and with the other probe press lightly on the track and move the second probe along the track.

e. A deflection should gradually be observed. The polarity of the deflection is not important, and depends on which clip and which probe is placed on which end of the track. If the deflection approaches full scale, move the stationary probe to the vicinity of the other probe to bring the meter reading back to zero, then continue the search for the short.

f. When an increase in the distance between the probes on the 50 uV range does not produce a corresponding increase in the meter deflection, either the point of the short has been passed, or the short is on a node branch that has just been passed. Back up the probe until a decrease in deflection occurs, then investigate.

3.4.2 Vcc-To-Ground Shorts.

Figure 3-3 illustrates a principal application for the microvoltmeter. A shorted capacitor is not an uncommon fault and can be easily found as illustrated. With the signal clips connected as shown, the dc current source flows through the shorted capacitor to ground. As the probe is moved along the power bus the deflection increases. As the point-of-short is passed no further IR drop occurs since there is no current flow through this path; the voltage point is at the same potential as the short (ground potential). Thus the deflection remains constant past the point-of-short.

3.4.3 Use of Microvoltmeter on Energized Board.

The microvoltmeter can be used on an energized system (power applied to the board-under-test) to resolve a short when system analysis pin-points a bad node. The following techniques illustrate the most common applications and can be used to determine, for example, if an IC driving a node is bad, or if one of the IC's receiving a signal from the identified node is bad (such as having an internal short to ground, Vcc, or another node.

Figure 3-4 illustrates current flow and level for standard TTL logic 0 and 1 states under normal conditions. Under fault conditions current is sourced to the short from all other points on the node, regardless of whether or not the point is an output or input (though the level will vary). Trouble-shooting using the microvoltmeter is easy if this concept is kept in mind. If current is flowing from an IC pin to a short, it is sourcing current. It is easily determined if any given IC pin is sourcing or sinking current. Simply place the positive (red) probe closer to the IC pin than the black (negative) probe. Place the black probe elsewhere

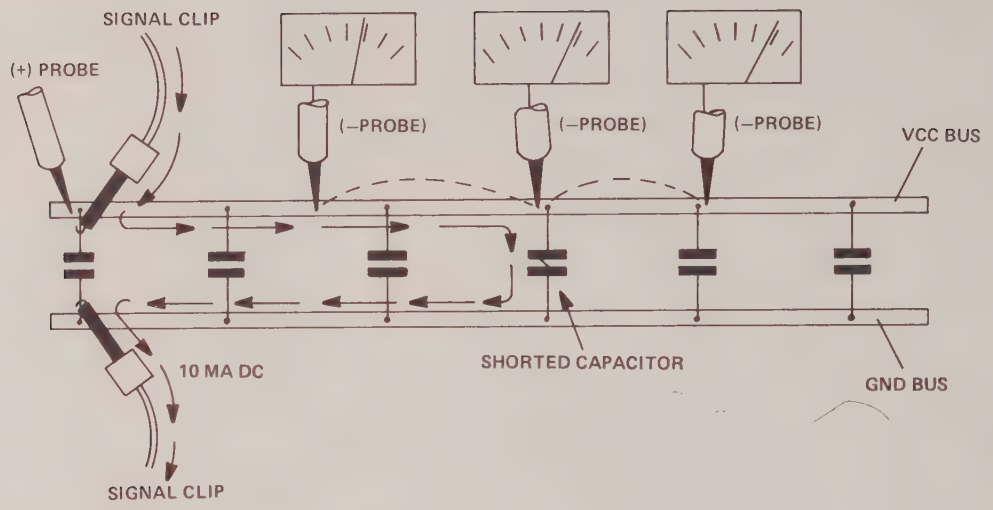

Figure 3-3. Probing Vcc-to-ground shorts.

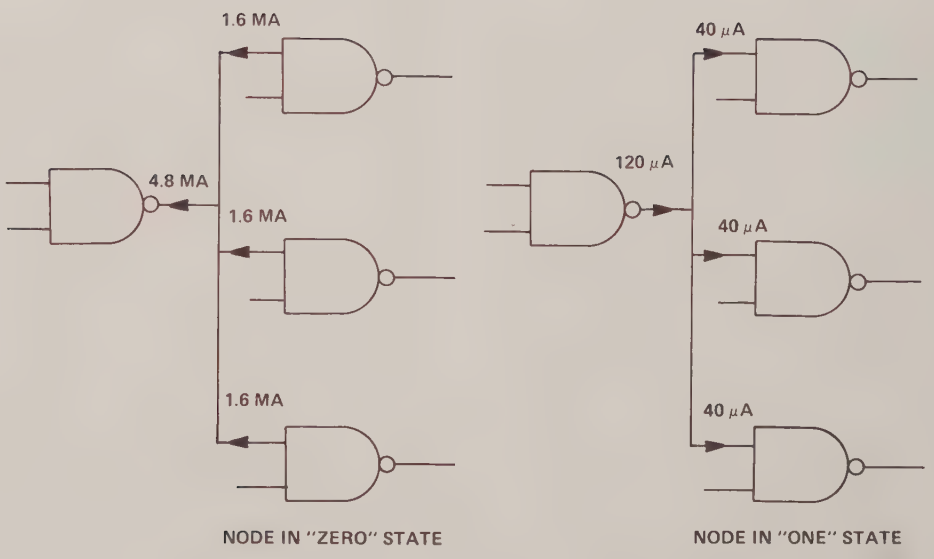

Figure 3-4. Standard TTL loading.

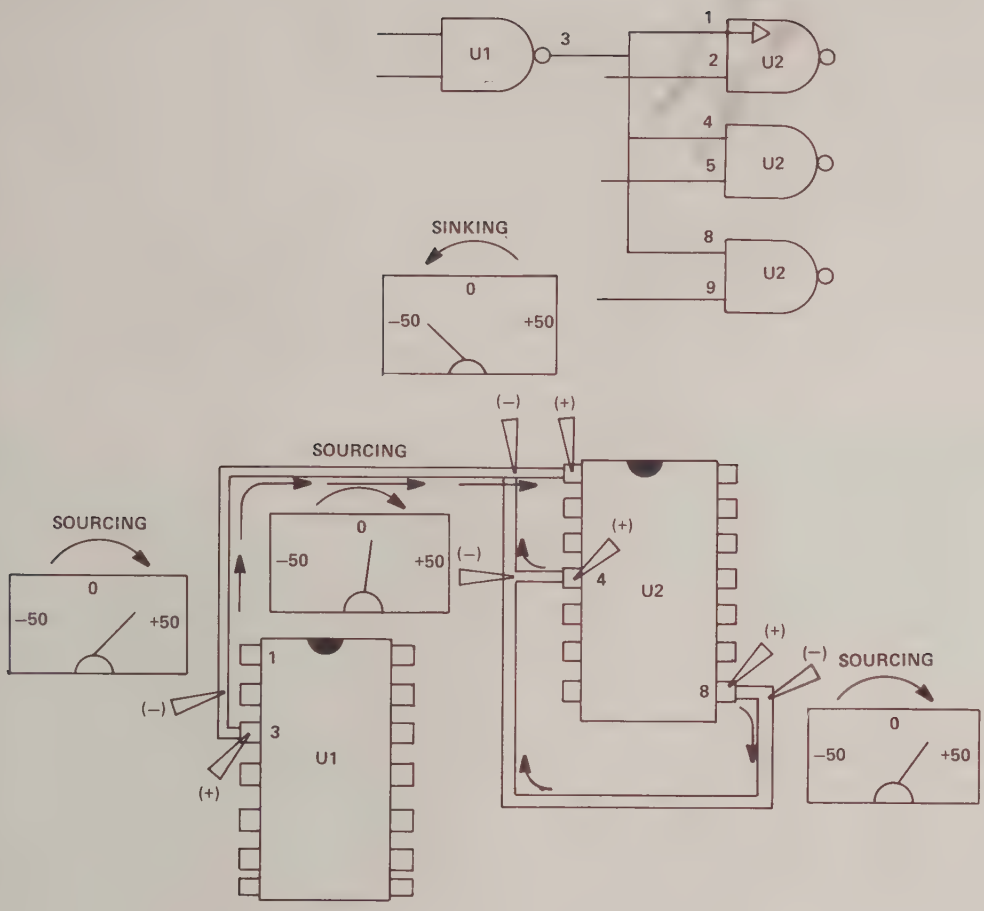

Figure 3-5. Probing an energized board.

on the node. If the meter deflects upscale, current is being sourced by this IC point; a down-scale deflection indicates it is sinking current.

Figure 3-5 illustrates an example of the most common type of probing on an energized board. In this example assume that U2-1 has an internal short to ground, and because of this the node "fails to go high". The board-under-test must be set-up by the test system to the failing condition. Figure 3-5 shows the node both from physical and electrical viewpoints. When U1-3 is probed, the positive deflection indicates that the pin is sourcing current. Similarly, when U2-8 and U2-4 are probed, positive indications are indicated, though of a much smaller magnitude. When U2-1 is probed as shown the deflection is negative indicating it is sinking current. This principle, carried one step further, is used if the short is somewhere in the track. Place the positive probe on the driving output (as with U1-3). Follow the track using the other probe. The deflection increases and is at a maximum at the short. If the short is passed the deflection will stay at approximately the same level or start moving down-scale as a result of the current being sourced from the node IC inputs (as from U2-4, and U2-8).

Open-Collector Logic. The technique just described applies to open-collector logic with one difference. In the logic high state a logic output of this type does not source current to the track. If, for example, a short to ground holds a node low, and a microvoltmeter measurement made at the pin driving the node indicates 0 uV, this output has not failed. If it is determined that this output is good, probe the other points on the node using the techniques previously described in para. 3.4.3 to trouble-shoot the short.

Theory–Section 4

4.1 GENERAL 4-1
4.2 CURRENT-TRACING PROBE (SIGNAL TRACE MODE) 4-1
4.3 CONNECTIVITY TEST 4-3
4.4 MICROVOLTMETER 4-3
4.5 SYSTEM POWER 4-4

4.1 GENERAL.

This section describes the theory of the current-tracing probe, the connectivity tester and the microvoltmeter. The theory for the microvoltmeter also includes the 10 mA dc current source. An understanding of this theory is helpful in performing any trouble analysis on the unit.

4.2 CURRENT-TRACING PROBE (SIGNAL-TRACE MODE).

4.2.1 Background.

The current-tracing probe is designed to detect the polarity (direction) of the magnetic field that is induced around a wire (etch) when a current is applied through the wire. Figure 4-1 illustrates the field relative to current flow and also shows that the induced voltage in the probe produces a current flow in a direction depending on which side of the track the probe lies on.

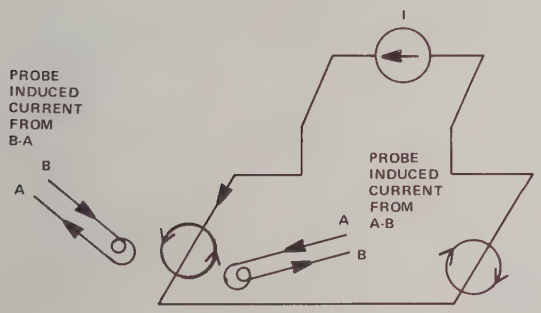

Figure 4-1. Magnetic field resulting from current flow through a wire.

Figure 4-2 is a simplified functional diagram of the probe. The signal clips are used to connect the ac current source (600 kHz) to two shorted nodes. The current-trace probe contains a coil that is tuned to detect the 600 kHz stimulus. A small ac voltage developed in the probe coil is amplified and applied to a phase detector. The phase detector compares the phase of the signal induced into the probe with the 600 kHz stimulus signal. From the phase detector it is determined whether the probe coil lies inside or outside of the current-carrying track. Two LED indicators are associated with the phase detector. Additionally, one of two audio tones indicates the phase.

4.2.2 1.2 MHz Oscillator and Clock Divider.

The 1.2 MHz oscillator (U3 and associated components) is the heart of the "current-sniffing" probe. The 600 kHz source stimulus is derived from this oscillator through a flip-flop frequency divider (U5). The divided output is also applied to the phase detector circuitry to synchronize it as described in para. 4.2.6.

The oscillator is tuned by L2, C15 and C16 to a frequency of approximately 1.2 MHz. C17 provides a fine-tune oscillator adjustment. C47 is a blocking capacitor required to prevent L2 from shorting U3-7 (base) to the gate (U3-3). C18 prevents L2 from shorting the gate (U3-3) to the source. U3 buffers the oscillator output and converts the oscillator sinewave to a square wave.

The OSC OFF signal to the oscillator (U3-5) is tied to either +5 V or –5 V through the OPERATING MODE switch section S5. When the Signal-Trace mode is selected, +5 V is switched in to enable the oscillator. For all other modes –5 V is switched in to disable the oscillator. This prevents oscillator pick-up from affecting the other modes of operation.

The clock-divider flip-flop U5 divides the oscillator frequency by 2, supplying a 600 kHz (approx.) signal from U5-1 to driver Q7. The output of U5-2 is applied to U4. The other input (U4-2) is approximately 1.2 MHz. The output of U4 provides the toggle for the phase detector. The timing relationships for the above signals are illustrated in Figure 4-3. The toggle (U4-3) is thus delayed one-fourth of a period from the probe excitation signal.

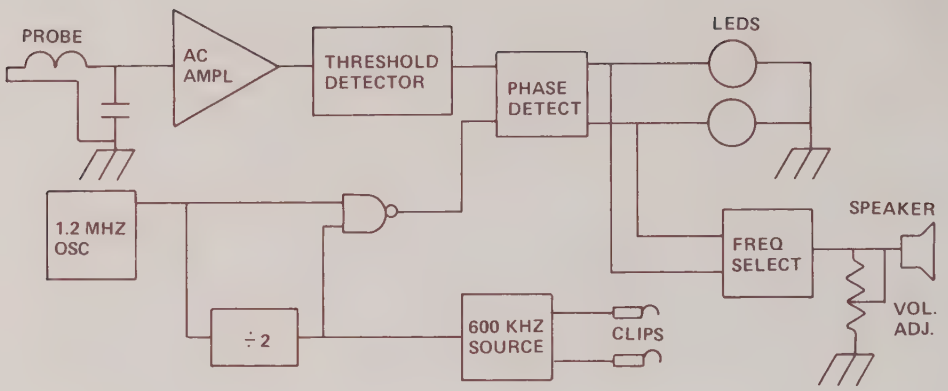

Figure 4-2. Current-trace probe simplified functional diagram.

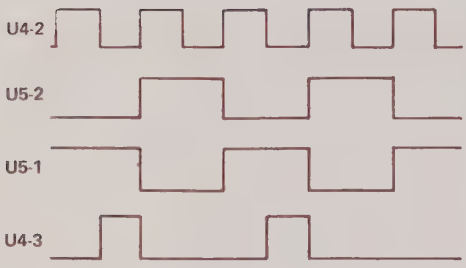

Figure 4-3. Oscillator and divider timing.

4.2.3 600 kHz Source Drive.

The 600 kHz signal from U5-1 is applied to the Q7/Q1 driver stage through R13/C12. The current is limited through R13. C13 minimizes the effect of stray capacitance both in the track and Q7 from attenuating the 600 kHz signal. Q7 and Q1 provide the source driver (20 ma nominal) required to force a current through a pc-board track to produce the magnetic field (para. 4.2.1). The 600 kHz output is protected from overload (accidental connection to a voltage source) to +/—15 V (max). CR20 is back-biased for +15 V.

4.2.4 Probe and Preamplifier.

The probe nose contains the tuned circuit L1 and C4. This circuit is resonant at 600 kHz. U1 is an ac-coupled amplifier with a gain of approximately 80 at 600 kHz. The amplified phase information is then applied to comparator U2. The comparator has a switchable hysterisis. Initially, the hysterisis is set at 100 mV pk-pk (R5/R11). When this threshold level is reached, the hysterisis is changed to 50 mV pk-pk by Q8/R48. The change of hysterisis ensures that the drive level is sufficient to produce positive startup and shutdown of U2. The comparator output (TP2) produces a +/—5 V signal swing when sufficient excitation (greater than 100 mV pk-pk) is applied to U1. The comparator output is applied to the phase-detector flip-flop.

4.2.5 Threshold Detector.

The comparator output is also applied to a threshold detector. The detector ensures that the tones and LED indicators are extinguished when the probe is not near the track being probed. C11 passes the comparator output to the detector. The positive-half of each 600 kHz cycle is conducted through CR18. This charges C30 positive. During the negative half-cycle CR23 conducts and C30 attempts to discharge through R10. The time constant is such however, that the next positive half-cycle is received before C30 is discharged. This maintains U4-5,6 positive which enables phase detector U5. When the comparator output is not active, C30 discharges through R10 and U4-5,6 are at a low logic level. The phase detector is then disabled.

4.2.6 Phase Detector.

The phase information is received by U5-9 and this flip-flop is clocked at U5-11 (para. 4.2.2). The logic level from the amplified induced signal from the probe is clocked to the the U5-13 output (PHASE 1) on the leading edge of the toggle pulse (U5-11). The LEDs CR14 and CR15 alternately blink back and forth as long as a phase difference is being detected. The current to the LEDs is limited by R12. Q5 and Q6 are drivers for CR14 and CR15, respectively. R16 and R40 limit the current that U5 is required to sink.

The complementary phase detector outputs PHASE 1 and PHASE 2 are applied to analog switches U15-5 and U15-6. PHASE 1, when high switches PULSE 2 through speaker drivers Q4/Q2 to the speaker. Similarly, PULSE 3 is switched through by PHASE 2. The PULSE 2 and PULSE 3 signals are produced as described in para. 4.4.2.

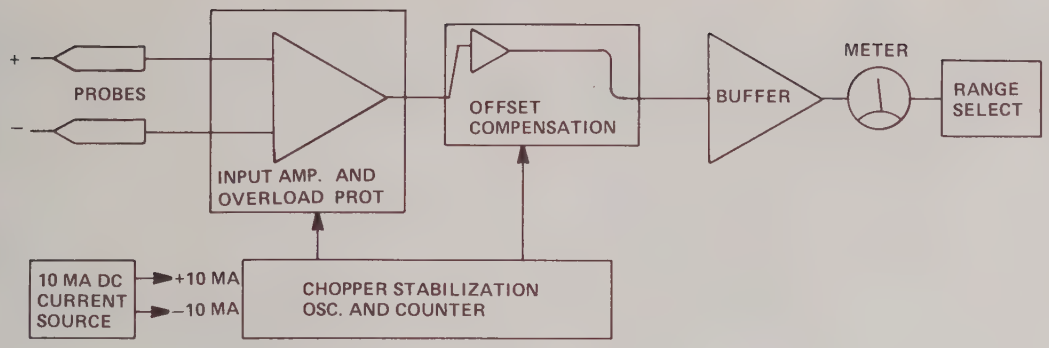

Figure 4-4. Microvoltmeter simplified diagram.

4.3 CONNECTIVITY TEST.

U10 and associated circuitry form the connectivity tester. The test probe leads are connected to a resistance divider consisting of R31, R32, and R42 on the U10-3 input. U10 is a comparator, and because of the divider on the input, the comparator output U10-7 (TP6) goes high when the test probes are connected to a resistance of less than 68 ohms. When this occurs analog switch U15-13 goes high and closes. The PULSE 2 signal on U15-1 is then applied through the Q4 and Q2 pulse amplifier stage to the speaker and earphone jack. The PULSE 2 tone (385 Hz) is generated by the U11 oscillator and U12 divide-by-eight counter (refer to para. 4.4.2) and is also used in the microvoltmeter mode.

4.4 MICROVOLTMETER.

4.4.1 General.

Figure 4-4 is a simplified block diagram of the microvoltmeter. The probed voltage is applied to overload protection circuits and then to the input amplifier. The amplifier is chopper-stabilized and provides gain. Chopper stabilization is a technique that minimizes the effects of U7 offset drift resulting from temperature variations. With this method the microvoltmeter input and ground are alternately sampled. Any offset voltage in U7 is stored in C23 during the time that ground is being sampled. The input voltage is then sampled and algebraically summed with the stored offset voltage. The two offset voltages cancel, leaving only the amplified input voltage which is stored on C25. When this voltage reaches +/—25 and +/—250 mV the microvoltmeter will be reading +/— full scale on the 50 and 500 uV ranges, respectively.

4.4.2 Input Stage.

The input stage has a low-input impedance of 100 ohms. This low impedance stabilizes the chopper switches at the input of U7 so the meter will remain at zero when the microvoltmeter is not being used. The input is protected against voltage overload to +/—15 V. Lamp DS1 provides this protection because its resistance increases and limits the current as the voltage across the lamp increases. Diodes CR16 and CR17 clamp the voltage to +/—1 V max. C41 along with DS1 form a low-pass filter designed to attenuate computer-clock frequencies and prevent an erroneous meter offset when the microvoltmeter is used on an energized board (para. 3.4.3). The filter cutoff is approximately 10 MHz. DS1 and R21 also form a voltage divider. Approximately a sixth of the input voltage is dropped by this network. This loss is compensated for by the gain of U7. C43 across the input of U7 shunts high frequencies to minimize switching transients produced by U6. C44 reduces 60 Hz pick-up from floating ground to case ground. U7 is configured as an ac-coupled amplifier. A gain of approximately 600 is developed by feedback resistors R23 and R24.

Analog switches U6-5, and -13 in the input stage are used for chopper stabilization, described in the next paragraph.

4.4.3 Chopper Stabilization - Oscillator and Counter.

The timing pulses for chopper-stabilization control are developed through oscillator U11, and divide-by-8 counter U12. The oscillator frequency of 3080 Hz is controlled by C29, R41, and R43 (adjustable). R43 is variable to adjust the chopper frequency away from any 50 or 60 Hz harmonics to avoid undesirable meter pulsation. R46 minimizes frequency drift resulting from any power instability. The oscillator output is applied to a divide-by-8 counter U12 to produce the PULSE 1,2,3 and PULSE 4 timing outputs as illustrated on the schematic (Figure 6-2). The timing pulses are applied to the U6 analog switches. A high pulse level closes a switch. As shown in the schematic, the input is opened (U6-5) when PULSE 1 goes low. At the same time PULSE 3 goes high to ground the microvoltmeter input (U6-13). This references U7 to floating ground. After the switching transients have decayed away and the operational amplifier has settled, the output voltage

of U7 will be in error by its output offset voltage. This settling time is the interval between the leading edge of PULSE 3 and PULSE 2. When PULSE 2 goes high analog switch U6-12 closes and provides a charging path for C23 to store the output offset voltage error on C23. PULSE 2 then returns low, opening switch U6-2. The microvoltmeter input switch is then closed (PULSE 1 high to U6-5) and the ground switch is opened (PULSE 3 low to U6-13). The input voltage is now amplified by U7. The output voltage including its offset error is algebraically summed with the stored offset on C23. The two offset errors cancel, leaving only the amplified field input voltage as the input to U8. This voltage is buffered by U8 and is ultimately stored on C25 when PULSE 4 closes U6-6.

4.4.4 Meter Amplifier.

Amplifier U9 converts the stored voltage on C25 to a current suitable to drive the +/—500 uA meter movement. Capacitors C19 and C26 filter out any switching noise that appears at the input. The meter itself is in the U9 feedback loop. R8 at the output of U9 limits the current to the meter to protect it from any overload presented to the microvoltmeter input. The output is inverted from the input and the stage has a unity dc gain with respect to the range resistors R29 and R30. The current through the range resistor is essentially equal to the meter current. R29 is selected and switched in by S2 when the front-panel 50 uV range Operating Mode is pressed. Similarly, R30 is switched in by S3 when the 500 uV range is selected.

4.4.5 10 MA Current Source.

The source of constant current is provided by transistor Q3 and associated components. This circuit is fully floating so that either current-source lead can be referenced to the microvoltmeter return. Zener diode CR9 and current diode CR10 (1 ma) establishes a fixed voltage drop across the base-emitter of Q3 and R1. This voltage is unaffected by power line fluctuations, therefore the output current remains constant. The source is applied to the signal clips whenever the microvoltmeter is selected.

4.5 SYSTEM POWER.

System power requirements are met with +5 V and —5 V potentials. These voltages are supplied to the unit through 0.5 A regulators U13 and U14, respectively. The unregulated 5 Vdc power is developed through a bridge rectifier (CR1-CR4) on the secondary of step-down transformer T1. C1 and C2 filter the unregulated dc power.

Service and Maintenance—Section 5

5.1 CUSTOMER SERVICE 5-1
5.2 INSTRUMENT RETURN 5-1
5.3 MINIMUM PERFORMANCE STANDARDS 5-1
5.4 ADJUSTMENTS 5-3
5.5 DISASSEMBLY AND ACCESS 5-3

CAUTION

For continued protection against fire hazard, replace fuse only with the same type and rating as shown on rear panel and in parts list.

WARNING — SHOCK HAZARD

Dangerous voltages are present inside this instrument. Refer all servicing to qualified personnel.

5.1 CUSTOMER SERVICE.

Our warranty (at the front of this manual) attests the quality of materials and workmanship in our products. If malfunction does occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone the nearest GenRad service facility (see back page), giving full information of the trouble and the steps taken to remedy it. Describe the instrument by name, catalog number, serial number, and ID (lot) number if any. (Refer to the front and rear panels.)

5.2 INSTRUMENT RETURN.

5.2.1 Returned Material Number.

Before returning an instrument to GenRad for service, please ask our nearest office for a "Returned Material" number. Use of this number in correspondance and on a tag tied to the instrument will ensure proper handling and identification. After the initial warranty period, please avoid unnecessary delay by indicating how payment will be made, i.e., send a purchase-order number.

5.2.2 Packaging.

To safeguard your instrument during storage and shipment, please use packaging that is adequate to protect it from damage, i.e., equivalent to the original packaging. Any GenRad field office can advise or provide packing material for this purpose. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here are two recommended packaging methods:

Rubberized Hair. Cover painted surfaces of the instrument with protective wrapping paper. Pack instrument securely in strong corrugated container (350 lb/sq. in bursting test), with 2-in rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and container to ensure a snug fit. Mark the box "Delicate Instrument" and seal with strong tape or metal bands.

5.3 MINIMUM PERFORMANCE STANDARDS.

5.3.1 General.

The following procedures are designed to verify the accuracy and overall performance of the instrument. The checks are controlled from the front panel, without the need for disassembly. Table 5-1 lists the equipment recommended for the following checks, trouble analysis, and making the adjustments described in para. 5.4. Also listed are the patch cords and connectors that can be used to make the connections described in the following paragraphs. The connectors and patch cords for the equipment specified can be purchased through the GR Catalog Sales Dept.

CAUTION

Be sure the rear-panel line voltage switch is correctly set for your power line voltage.

5.3.2 380 Hz Oscillator Check.

To perform this check it is necessary to connect two resistors (a 1 Ω 1% and a 10 KΩ 1%) in series, and then connect both an oscillator and a frequency counter (to measure period) across the resistors. The 2220 red and black test probes are placed across the 1 Ω (red lead to the junction of the resistors).

a. Turn the 2220 On and set it to the 500 uV range.

b. Turn on the oscillator and set it to approx. 380 Hz, with the output amplitude to approx. 5 Vpk-pk using an oscilloscope.

c. Vary the oscillator frequency slightly until the 2220

Table 5-1

RECOMMENDED EQUIPMENT FOR MINIMUM PERFORMANCE, TROUBLE ANALYSIS AND ADJUSTMENTS

Name	Requirement	Recommended Type*
Resistors	1 Ω 1% 10 Ω 1% 61.9 Ω 1% 82.5 Ω 1% 10 kΩ 1% 100 kΩ 1%	–
Oscilloscope	General purpose, 100 MHz	Tektronix 465
Oscillator	Variable 500 Hz, 5 V pk-pk output	GR1310-B
Frequency Counter	50 MHz, and period measurement	GR1192-B
Connectors	(3) Black Binding Post Assemblies	GR 0938-9708
Patch Cords	Banana plug, double in-line (2) Banana plug, single	GR 0274-9860 GR 0776-9702
Adaptors	GR874® Connector and Binding Posts GR987® Connector to BNC	GR 0874-9810 GR 0874-9800
Power Supply	Variable 0-5 Vdc	Kepco ABC 15-1 M
Voltmeter	Digital, general purpose	Data Precision 1450

*Equivalents may be substituted.

meter begins to swing back and forth. Continue adjusting the frequency until the 2220 meter swing rate is less than 1 Hz.

d. Turn on the frequency counter and set it to read a time period. The period should be between 2.5774 and 2.6826 ms.

5.3.3 Microvoltmeter Accuracy Check.

To perform this check make the following equipment connections, then change the setup as indicated in the test procedure.

a. Connect two resistors (100 kΩ 1% and 1 Ω 1%) in series.

b. Connect a 0-5 Vdc power supply, and the voltmeter across the resistors (supply and meter positive leads to the 100 kΩ resistor).

Perform the following steps:

a. Turn the 2220 On and set to the 50 uV range.

b. With the 2220 test probes open circuited and then shorted together, the meter should remain within ±10 uV.

c. Place the 2220 test probes (not the signal clips) the 1 Ω resistor (red probe to the junction of the resistors).

d. Turn on and adjust the power supply until the 2220 meter reads full scale (50 uV). The dvm should now read from +3 to +7−V.

e. Interchange the test probes across the 1 Ω resistor to reverse the polarity and repeat step d. (Adjust meter to minus f.s.).

f. Turn off the power supply.

g. Replace the 100 kΩ resistor with a 10 kΩ 1% resistor.

h. Set the 2220 to the 500 uV range.

i. Repeat steps c. through f. for both polarities of the 500 uV range.

5.3.4 10 mA Dc Current Source Check.

The dc current source is checked by connecting the load resistor (10 Ω) across the 2220 signal clips. The source is turned on when the 2220 is placed in the microvoltmeter mode. The dc current drive is checked by measuring the voltage drop across the 10 Ω resistor resulting from the current applied through it.

Perform the following steps:

a. Turn on the 2220 and set it to the 50 uV range.

b. Connect the 2220 signal clips (not the test probes) across a 10 Ω 1% resistor.

c. Turn on the oscilloscope and adjust it to observe a voltage measurement that should be between 80 mV and 120 mV.

d. Set the 2220 to the 500 uV range and repeat step c.

e. Remove the resistors and connect the oscilloscope directly across the 2220 signal clips. The voltage measured should not exceed 1 Vdc max.

5.3.5 600 kHz Check.

The 600 kHz signal trace current is checked by connecting a load resistor (10 Ω) across the 2220 signal clips. The source is turned on when the 2220 is placed in the signal trace mode. The current drive is checked by measuring the voltage drop across the 10 Ω resistor resulting from the ac signal current applied through it.

Perform the following steps:

a. Turn on the 2220 and set it to the Signal trace mode.

b. Connect the 2220 red and black signal clips (not the test probes) across a 10 Ω 1% resistor.

c. Turn on the oscilloscope and connect it across the

resistor. Adjust the scope such that a square-wave pulse from 160 to 240 mV pk-pk with an approximate period of 1.7 us can be observed.

d. Remove the resistor. A pulse of approx. 500 mV should be observed.

5.3.6 Connectivity Mode Check.

A resistance of less than approximately 68 Ω detected across the test probes results in a tone from the 2220 speaker when the unit is in the connectivity mode. This threshold is not critical and is easily checked by placing two precision resistors with values that are near but above and below the threshold.

Perform the following steps:

a. Turn on the 2220 and set it to the Connectivity mode.

b. Turn the 2220 front-panel volume control up (cw).

c. Touch the test probes (not the signal clips) together. A tone should be heard.

d. Touch the probes across a 61.9 Ω resistor. A tone should be heard.

e. Touch the probes across an 82.5 Ω resistor. There should be no tone.

5.4 ADJUSTMENTS.

5.4.1 General.

The 2220 has only a few factory-preset adjustments that ensure peak performance. Before any of the following adjustments are made check for a mechanical zero with the unit turned off. Adjust this zero with the meter-face screw adjustment. Then turn the unit on and let it warm up for 5 minutes before performing any of the following adjustments. The adjustments referred to below can be located by referring to Figure 5-1.

5.4.2 Microvoltmeter Adjustments.

380 Hz Oscillator Adjustment. The oscillator is adjusted through the setting of R43. Perform the following:

a. Connect a frequency counter to U11-10 (PULSE 1).

b. Adjust R43 until a reading of 379 ±7 Hz is obtained (period measurement of 2.590 to 2.688 ms).

Microvoltmeter Dc Offset Adjustment. Perform the following steps to zero the microvoltmeter.

a. Set the Bug Hound to the 50-μV mode.

b. Touch the microvoltmeter red and black probes together (not the signal clips) to short the meter input. Do not hold the probe tips with your fingers because your body heat can induce small thermal emf's in the probes that can shift the meter zero.

c. While observing the meter, adjust R25 for a zero meter deflection.

5.4.3 1.2 MHz Oscillator Adjust (Signal-Trace Mode).

The proper oscillator setting from which the 600 kHz drive signal is derived is not exactly 1.2 MHz. The oscillator frequency is set to the value that produces the maximum probe pre-amplifier response (TP1) on the output of U1. Perform the following:

a. Set the OPERATING MODE switch to Signal Trace.

b. Clip the red and black signal clips together.

c. Connect an oscilloscope to TP1.

d. Hold the wire of one of the joined signal clips against the side of the current-trace probe at the probe tip. Position the wire and probe for maximum response at TP1, and hold them steady until step e. is completed.

e. While observing the oscilloscope, adjust C17 for a maximum amplitude.

5.5 DISASSEMBLY AND ACCESS.

Perform the following to access and remove the 2220-4700 Current-Trace Probe Board that contains most of the Bug Hound circuitry. The remaining circuitry including the meter, power transformer, etc. are easily accessed without removal from the chassis.

CAUTION

Observe the following precautions whenever you handle a circuit board or integrated circuit in this instrument.

MOS HANDLING PRECAUTIONS

- **Place the instrument and parts on a grounded, conductive work surface.**
- **Ground yourself (with a strap having approx. 1 MΩ.)**
- **Ground the frame of any test instrument or soldering iron used.**
- **If the circuit board is to be stored or transported, enclose it in a conductive (anti-static) envelope.**

a. Turn the unit upside down and remove the 4 screws from the chassis shell.

b. Slide the unit forward in the shell, and tip it up (toward the bottom of the chassis) and out.

To Remove the board:

c. Unplug the three connector blocks from their sockets on the board. Also, disconnect the 4 probe leads from the board (J27-Red, J28-Black, J20-Center, J21-Shield-Brown).

d. Remove the 6 screws that hold the board to the chassis. The board can now be carefully removed from the chassis. Lift it up to the rear so that the Operating Mode switch assembly clears the chassis holes.

e. Reverse the above procedure to re-assemble the unit.

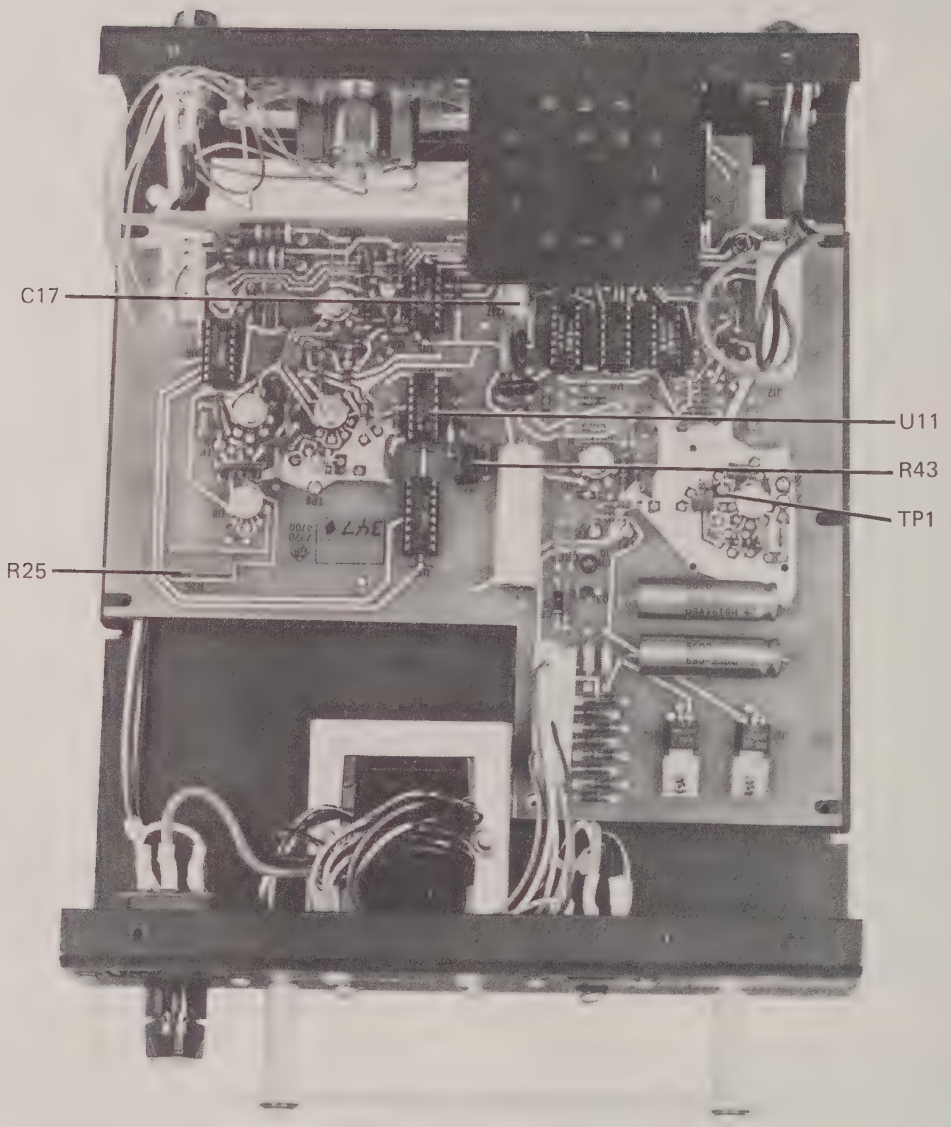

Figure 5-1. Interior — showing adjustments.

Parts Lists and Diagrams—Section 6

6.1 GENERAL 6-1
6.2 REFERENCE DESIGNATIONS 6-1
6.3 DIAGRAMS 6-1
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Figure 6-3. Bug Hound circuit board composite 6-9

6.1 GENERAL.

This section contains the parts lists, circuit-board layout drawing and schematic for the instrument. (Section 4 contains functional block diagrams. Reference designation usage is described below.

6.2 REFERENCE DESIGNATIONS.

Each electrical part on an assembly is identified on equipment and drawings by means of a reference designator comprised of numbers and letters. Component types on an assembly are numbered sequentially, the numbers being preceded by a letter designation that identifies the component (R for resistor, C for capacitor, etc.). Some of the less obvious designators are: DS, lamp; Q, transistor; U, integrated circuit; CR, diode; WT, wire tie point; J,P, connector.

6.3 DIAGRAMS.

The diagrams in this section are listed above. The unit consists of one board. The schematic for this board is Figure 6-2. The electrical components not mounted on the board (including the power transformer, meter, and others) are however shown in Figure 6-2.

Table 6-1
ACCESSORIES SUPPLIED

Quantity	Description	Part No.
1	Power cord, 210 cm (7 ft) long, 3-wire, AWG No. 18, with molded connector bodies.	4200-9625
1	Red and black test probes (set of 2 probes)	8160-0700
1	Red and black source clips (set of 2 probes)	2220-0220
1	Trace probe Asm.	2220-9710
1	Earphone	1935-9601

MECHANICAL PARTS LIST

Fig Ref	Quantity	Description	GR Part No.	FMC No.	Mfgr. No.
1	1	Shell	2220-8000	24655	2220-8000
2	1	Current Source Clip Asm.	2220-0220	24655	2220-9720
3	1	Power Plug Connector	4240-0250	82389	EAC-302
4	1	Handle	2220-8020	24655	2220-8020
5	1	Mounting Clip	5640-2405	06915	V-1001
6	1	Test Probe Set	8160-0700	24655	8160-0700
7	1	Fuse Holder	5650-0100	75915	342-004
8	1	Mounting Clip	5640-2408	06915	V-1004
-	1	Earphone (P1)-(not shown)	1935-9601	24655	1935-9601
9	1	Earphone Jack (J1)	4260-1110	82389	TR-2A
10	1	Trace Probe Asm.	2220-9710	24655	2220-4000
11	1	Bail	5250-2123	24655	5250-2123
12	2	Foot, soft	5260-2060	24655	5260-2060
13	1	Knob	5520-5133	24655	5520-5133

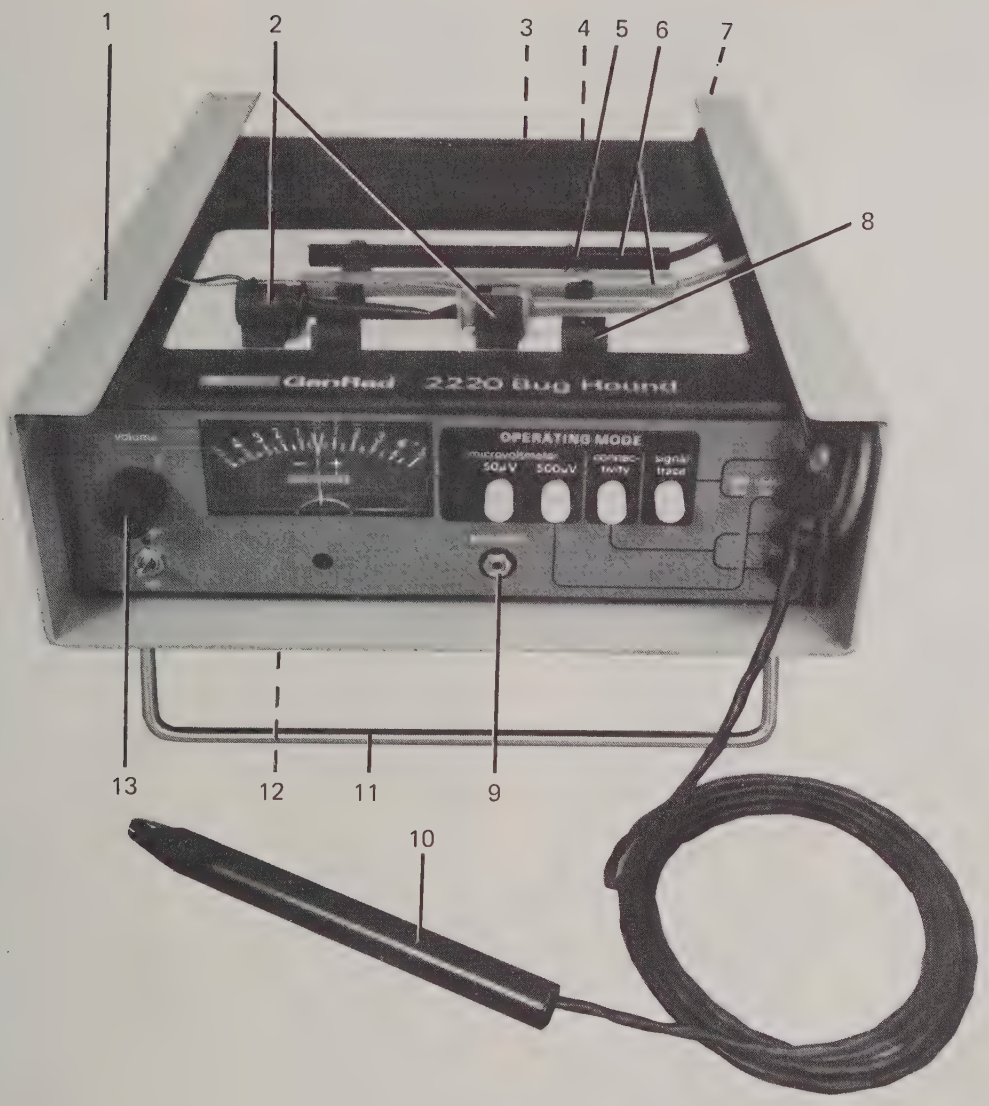


Figure 6-1. Replaceable mechanical parts.

FEDERAL SUPPLY CODE FOR MANUFACTURERS

From Defense Logistics Agency Microfiche
H4-2 SB 708-42 GSA-FSS H4-2

Ref FMC Column in Parts Lists

Code	Manufacturer
00136	McCoy Elctrns.,Mt.Holly Springs,PA 17065
00192	Jones Mfg.,Chicago,IL 60181
00194	Walsco Elctrns.,Los Angeles,CA 90018
00327	Welwyn Intntl.,Westlake,OH 44145
00434	Schweber Elctrns.,Westburg,NY 11590
00656	Aerovox.,New Bedford,MA 02745
00779	AMP Inc.,Harrisburg,PA 17105
01009	Alden Products.,Brockton,MA 02413
01121	Allen Bradley.,Milwaukee,WI 53204
01255	Litton Inds.,Beverly Hills,CA 90213
01281	TRW.,Lawndale,CA 90260
01295	TI.,Dallas,TX 75222
01526	GE.,Waynesboro,VA 22980
01930	Amerock.,Rockford,IL 61101
01963	Cherry Elctrc.,Waukegan,IL 60085
02111	Spectrol Elctrns.,City of Industry,CA 91745
02114	Ferroxcube ,Saugerties,NY 12477
02606	Fenwall Lab.,Morton Grove,IL 60053
02639	GE.,Schenectady,NY 12307
02660	Amphenol.,Broadview,IL 60153
02735	RCA.,Somerville,NJ 08876
02788	Fastex.,Desplains,IL 60016
03042	Carter Ink.,Cambridge,MA 02142
03508	GE.,Syracuse,NY 13201
03550	Vanguard Elctrns.,Inglewood,CA 90302
03636	Grayburne.,Yonkers,NY 10701
03877	Transitron Elctrns.,Wakefield,MA 01880
03888	KDI Pyrofilm.,Whippany,NJ 07981
03911	Clairex.,New York,NY 10001
04009	Arrow Hart.,Hartford,CT 06106
04643	Digitronics.,Albertson,NY 11507
04713	Motorola.,Phoenix,AZ 85008
04919	Component Mfg.,W.Bridgewater,MA 02379
05079	Tansistor Elctrns.,Bennington,VT 05201
05245	Corcom.,Chicago,IL 60639
05276	ITT Elctrns.,Pomona,CA 91766
05402	Controls Co.of Amer.,Melrose Pk,IL 60160
05574	Viking Inds.,Chatsworth,CA 91311
05624	Barber Colman.,Rockford,IL 61101
05748	Barnes Mfg.,Mansfield,OH 44901
05820	Wakefield Eng.,Wakefield,MA 01880
06383	Panduit.,Tinley Pk,IL 60477
06406	Truelove & Maclean.,Waterbury,CT 06708
06665	Precision Monolith.,Santa Clara,CA 95050
06743	Clevite.,Cleveland,OH 44110
06795	WLS Stamp.,Cleveland,OH 44104
06815	Richco Plstc.,Chicago,IL 60646
06928	Teledyne Kntcs.,Soland Bch,CA 92075
06978	Aladdin Elctrns.,Nashville,TN 37210
07047	Ross Milton.,Southampton,PA 18966
07126	Digitran.,Pasadena,CA 91105
07127	Eagle Signal.,Baraboo,WI 53913
07233	Cinch Graphik.,City of Industry,CA 91744
07261	Avnet.,Culver City,CA 90230
07263	Fairchild.,Mountain View,CA 94040
07387	Birtcher.,N.Los Angeles,CA 90032
07595	Amer.Semicond.,Arlington Hts,IL 60004
07699	Magnetic Core.,Newburgh,NY 12550
07707	USM Fastener.,Shelton,CT 06484
07828	Bodine.,Bridgeport,CT 06605
07829	Bodine Elctrc.,Chicago,IL 60618
07910	Cont Device.,Hawthorne,CA 90250
07983	State Labs.,New York,NY 10003
07999	Borg Inst.,Delavan,WI 53115
08524	Deutsch Fastener.,Los Angeles,CA 90045
08556	Bell Elctrc.,Chicago,IL 60632
08730	Vemaline Prod.,Franklin Lakes,NJ 07417
09213	GE.,Buffalo,NY 14220
09353	C&K Components.,Watertown,MA 02172
09408	Star-Tronics.,Georgetown,MA 01830
09823	Burgess Battery.,Freeport,IL 61032
09856	Fenwal Elctrns.,Framingham,MA 01701
09922	Burndy.,Norwalk,CT 06852
10025	Glasseal Prod.,Linden,NJ 07036
10389	Chicago Switch.,Chicago,IL 60647
11236	CTS of Berne.,Berne,IN 46711
11599	Chandler Evans.,W.Hartford,CT 06101
11983	Nortronics.,Minneapolis,MN 55427
12040	National.,Santa Clara,CA 95051
12045	Elctrc Transistors.,Flushing,NY 11354
12498	Teledyne.,Mountain View,CA 94043
12617	Hamlin.,Lake Mills,WI 53551
12672	RCA.,Woodbridge,NJ 07095
12697	Clarostat.,Dover,NH 03820
12856	Micrometals.,City of Industry,CA 91744
12954	Dickson Elctrns.,Scottsdale,AZ 85252
12969	Unitrode.,Watertown,MA 02172
13094	Electrocraft.,Hopkins,MN 55343
13103	Thermalloy.,Dallas,TX 75234
13148	Vogue Inst.,Richmond Hill,NY 11418
13150	Vernitron.,Laconia,NH 03246
13327	Solitron Devices,Tappan,NY 10983
13715	Fairchild.,San Rafael,CA 94903
13919	Burr Brown.,Tucson,AZ 85706
14010	Anadex Inst.,Van Nuys,CA 91406
14195	Elctrc Controls.,Wilton,CT 06897
14196	American Labs.,Fullerton,CA 92634
14332	Relton.,Arcadia,CA 91006
14433	ITT.,W.Palm Beach,FL 33402
14482	Watkins & Johnson.,Palo Alto,CA 94304
14608	Corbin.,Berlin,CT 06037
14655	Cornell Dubilier.,Newak,NJ 07101
14674	Corning Glass.,Corning,NY 14830
14749	Acopian.,Easton,PA 18042
14752	Electrocube.,San Gabriel,CA 91776
14889	R&G Sloan.,Sun Valley,CA 91352
14908	Elctrc Inst & Spclty.,Stoneham,MA 02180
14936	General Inst.,Hicksville,NY 11802
15238	ITT.,Lawrence,MA 08142
15476	Digital Equip ,Maynard,MA 01754
15605	Cutler Hammer ,Milwaukee,WI 53202
15782	Houston Inst.,Bellaire,TX 77401
15801	Fenwal Elctrns.,Framingham,MA 01701
15819	Sinclair & Rush.,St.Louis,MO 63111
16037	Spruce Pine Mica.,Spruce Pine,NC 28777
16068	Intntl Diode.,Jersey City,NJ 07304
16179	Ommi Spectra.,Farmington,MI 48024
16301	Astrolab.,Linden,NJ 07036
16352	Codi.,Fairlawn,NJ 07410
16485	Sterling Inst.,New Hyde Park,NY 11040
16636	Indiana General.,Oglesby,IL 61348
16758	Delco.,Kokomo,IN 46901
16950	Precision Dynamics.,Burbank,CA 91504
16952	Amer Micro Devices.,Summerville,SC 29483
17117	Elctrc Molding.,Woonsocket,RI 02895
17540	Mohawk Spring.,Schiller Park,IL 60176
17745	Angstrohm Precsn.,Hagerstown,MD 21740
17771	Singer.,Somerville,NJ 08876
17850	Zeltex.,Concord,CA 94520
17856	Siliconix.,Santa Clara,CA 95054
18324	Signetics.,Sunnyvale,CA 94086
18542	New Prod Eng ,Wabash,IN 46992
18677	Scanbe.,El Monte,CA 91731
18736	Computer Diode.,S.Fairlawn,NJ 07936
18795	Cycon.,Sunnyvale,CA 94086
18911	Durant.,Watertown,WI 53094
19178	Zero.,Monson,MA 01057
19209	GE.,Gainesville,FL 32601
19373	Eastron.,Haverhill,MA 01830
19396	Paktron.,Vienna,VA 22180
19617	Cabtron.,Chicago,IL 60622
19644	LRC Elctrns.,Horseheads,NY 14845
19701	Electra.,Independence,KS 67301
20093	Elect Inds.,Murray Hill,NJ 07974
20754	KMC.,Long Valley,NJ 07853
21335	Fafnir Bearing.,New Britian,CT 06050
21688	Raytheon.,Norwood,MA 02062
21759	Lenox Fugle.,Watchung,NJ 07060
22526	Berg Elctrcs.,New Cumberland,PA 17070
22589	Electro Space Fabrctrs.,Topton,PA 19562
22753	UID Elctrcs.,Hollywood,FL 33022
23338	Wavetek ,San Diego,CA 92112
23342	Avnet Elctrcs.,Franklin Park,IL 60131
23936	Pamotor.,Bulingham,CA 94010
24351	Indiana Genrl Elctrc.,Keasby,NJ 08832
24355	Analog Devices.,Cambridge,MA 02142
24444	General Semicond.,Tempe,AZ 85281
24446	GE.,Schenectady,NY 12305
24454	GE.,Syracuse,NY 13201
24455	GE.,Cleveland,OH 44112
24602	EMC Technlgy.,Cherry Hill,NJ 08034
24655	Gen Rad. Concord,MA 01742
24759	Lenox Fugle.,S.Plainfield,NJ 07080
25008	Vactite.,Berkeley,CA 94710
25289	EG&G.,Bedford,MA 01730
26601	Tri-County Tube.,Nunda,NY 14517
26805	Omni Spectra.,Waltham,MA 02154
26806	American Zettler.,Costa Mesa,CA 92626
27014	National.,Santa Clara,CA 95051
27545	Hartford Universal Ball.,Rocky Hill,CT 06067
28480	HP.,Palo Alto,CA 94304
28520	Heyman Mfg.,Kenilworth,NJ 07033
28875	IMC Magnetics.,Rochester,NH 03867
28959	Hoffman Elctrcs.,El Monte,CA 91734
30043	Solid State Devices.,LaMirada,CA 90638
30646	Beckman Inst.,Cedar Grove,NJ 07009
30874	IBM.,Armonk,NY 10504
30985	Permag Magnetics.,Toledo,OH 43609
31019	Solid State Scntfc.,Montgomerville,PA 18936
31514	Standford Appld Engs.,Costa Mesa,CA 92626
31814	Analogic.,Wakefield,MA 01880
31951	Triridge.,Pittsburgh,PA 15231
32001	Jensen.,Chicago,IL 60638
33095	Spectrum Control.,Fairview,PA 16415
33173	GE.,Owensboro,KY 42301
34141	Koehler.,Marlboro,MA 01752
34156	Semicoa.,Costa Mesa,CA 92626
34333	Silicon Genrl.,Westminster,CA 92683
34335	Advanced Micro Devices.,Sunnyvale,CA 94086
34649	Intel.,Santa Clara,CA 95051
34677	Solitron Devices.,Jupiter,FL 33458
35929	Constanta.,Montreal,QUE,CAN
36462	National Ltd.,Montreal,QUE,CAN
37942	Mallory.,Indianapolis,IN 46206
38443	Marlin Rockwell.,Jamestown,NY 14701
39317	McGill Mfg.,Valparaiso,IN 46383
40931	Honeywell.,Minneapolis,MN 55408
42190	Muter.,Chicago,IL 60638
42498	National.,Melrose,MA 02176
43334	New Departure-Hyatt.,Sandusky,OH 44870
43991	Norma Hoffman.,Stanford,CT 06904
49671	RCA.,New York,NY 10020
49956	Raytheon.,Waltham,MA 02154
50088	Mostek.,Carrollton,TX 75006
50101	GHZ Devices.,S.Chelmsford,MA 01824
50507	Micro Networks.,Worcester,MA 01606
50522	Monsanto.,Palo Alto,CA 94304
50721	Datel Systems.,Canton,MA 02021
51167	Aries Elctrcs.,Frenchtown,NJ 08825
51553	Diablo Systems.,Hayward,CA 94545
51642	Centre Eng.,State College,PA 16801
52648	Passev.,Santa Ana,CA 92705
52676	SKF Inds.,Philadelphia,PA 19132
52763	Stettner Trush.,Cazenovia,NY 13035
53021	Sangamo Elctrc.,Springfield,IL 62705
53184	Xcitron.,Latham,NY 12110
53421	Tyton.,Milwaukee,WI 53209
54294	Shallcross ,Selma,NC 27576
54297	Assoc Prec Prod.,Huntsville,AL 35805
54715	Shure Bros.,Evanston,IL 60202
56289	Sprague.,North Adams,MA 01247
57771	Stimpson.,Bayport,NY 11705
58553	Superior Valve.,Washington,PA 15301
59730	Thomas & Betts.,Elizabeth,NJ 07207
59875	TRW.,Cleveland,OH 44117
60399	Torrington.,Torrington,CT 06790
61007	Townsend.,Braintree,MA 02184
61637	Union Carbide.,New York,NY 10017
61864	United Carr Fast.,Boston,MA
63060	Victoreen.,Cleveland,OH 44104
63743	Ward Leonard.,Mt.Vernon,NY 10550
65083	Westinghouse.,Bloomfield,NJ 07003
65092	Weston.,Newark,NJ 07114
70106	Acushnet Cap.,New Bedford,MA 02742
70109	Adams & Westlake.,Elkhart,IN 46514
70417	Chrysler.,Detroit,MI 48231
70485	Atlantic India Rubber.,Chicago,IL 60607
70563	Amperite.,Union City,NJ 07087
70611	Ark-Les Switch.,Watertown,MA 02172
70892	Bead Chain ,Bridgeport,CT 06605
70903	Belden.,Chicago,IL 60644
71126	Bronson.,Beacon Falls,CT 06403
71279	Cambridge Thermionic.,Cambridge,MA 02138
71294	Canfield.,Clifton Forge,VA 24422
71400	Bussmann,St.Louis,MO 63107
71450	CTS.,Elkhart,IN 46514
71468	Cannon.,Los Angeles,CA 90031
71482	Clare.,Chicago,IL 60645
71590	Centralab.,Milwaukee,WI 53212
71666	Continental Carbon.,New York,NY
71707	Coto Coil.,Providence,RI 02905
71729	Crescent Box.,Philadelphia,PA 19134
71744	Chicago Min Lamp.,Chicago,IL 60640
71785	Cinch.,Chicago,IL 60624
71823	Darnell.,Downey,CA 90241
72136	Electromotive.,Willimantic,CT 06226
72228	Continental Screw.,New Bedford,MA 02742
72259	Nytronics.,Berkeley Hts,NJ 07922
72619	Dialight.,Brooklyn,NY 11237
72699	General Inst.,Newark,NJ 07104
72765	Drake.,Chicago,IL 60631
72794	Dzus Fastener.,W.Islip,NY 11795
72825	Eby.,Philadelphia,PA 19144
72962	Elastic Stop Nut.,Union,NJ 07083
72982	Erie.,Erie,PA 16512
73445	Amperex Elctrcs.,Hicksville,NY 11801
73559	Carling Elctrc.,Hartford,CT 06110
73690	Elco Resistor.,New York,NY
73803	TI.,Attleboro,MA 02703
73899	JFD Elctrcs.,Brooklyn,NY 11219
73957	Groov-Pin.,Ridgefield,NJ 07657
74193	Heinemann.,Trenton,NJ 08602
74199	Quam Nichols.,Chicago,IL 60637
74445	Hole-Some.,Hartford,CT 06110
74545	Hubbell,Stratford,CT 06497
74861	Industrial Cndnsr.,Chicago,IL 60618
74868	Amphenol.,Danbury,CT 06810
74970	Johnson.,Waseca,MN 56093
75042	IRC(TRW).,Burlington,IA 52601
75376	Kurz-Kasch.,Dayton,OH 45401
75382	Kuka.,Mt Vernon,NY 10551
75491	Lafayette.,Syosset,NY 11791
75608	Linden.,Providence,RI 02905
75915	Littelfuse.,Des Plains,IL 60016
76005	Lord Mfg.,Erie,PA 16512
76149	Mallory Elctrc.,Detroit,MI 48204
76241	Maurey.,Chicago,IL 60616
76381	3 M Co.,St.Paul,MN 55101
76385	Minor Rubber.,Bloomfield,NJ 07003
76487	Millen.,Malden,MA 02148
76545	Mueller Elctr.,Cleveland,OH 44114
76684	National Tube.,Pittsburg,PA
76854	Oak Inds.,Crystal Lake,IL 60014
77068	Dot Fastener.,Waterbury,CT 06720
77147	Patton MacGuyer.,Providence,RI 02905
77166	Pass Seymour.,Syracuse,NY 13209
77263	Pierce Roberts Rubber.,Trenton,NJ 08638
77315	Platt Bros.,Waterbury,CT 06720
77339	Positive Lockwasher.,Newark,NJ
77342	AMF.,Princeton,IN 47570
77542	Ray-o-Vac.,Madison,WI 53703
77630	TRW.,Camden,NJ 08103
77638	General Inst.,Brooklyn,NY 11211
78189	Shakeproof.,Elgin,IL 60120
78277	Sigma Inst.,Braintree,MA 02184
78429	Airco Speer.,St Marys,PA 15867
78488	Stackpole.,St Marys,PA 15867
78553	Tinnerman.,Cleveland,OH
78711	Telephonics.,Huntington,NY 11743
79089	RCA.,Harrison,NJ 07029
79136	Waldes Kohinoor.,New York,NY 11101
79497	Western Rubber.,Goshen,IN 46526
79725	Wiremold.,Hartford,CT 06110
79727	Continental Wirt.,Philadelphia,PA 19101
79840	Mallory Controls.,Frankfort,IN 46041
79963	Zierick.,Mt Kisco,NY 10549
80009	Tektronix.,Beaverton,OR 97005
80030	Prestole Fastener.,Toledo,OH 43605
80048	Vickers,St Louis,MO 63166
80103	Lambda.,Melville,NY 11746
80183	Sprague.,N.Adams,MA 01247
80211	Motorola.,Franklin Pk,IL 60131
80251	Fornica.,Cincinnati,OH 45232
80258	Standard Oil.,Lafeyette,IN 47902
80294	Bourns Labs.,Riverside,CA 92506
80368	Sylvania.,New York,NY 10017
80431	Air Filter.,Milwaukee,WI 53218
80583	Hammarlund.,New York,NY 10010
80740	Beckman Inst.,Fullerton,CA 92634
80756	TRW Ramsey.,St Louis,MO 63166
80894	Pure Carbon.,St Marys,PA 15857
81030	Int'l Inst.,Orange,CT 06477
81073	Grayhill.,LaGrange,IL 60525
81143	Isolantite.,Stirling,NJ 07980
81312	Winchester.,Oakville,CT 06779
81349	Military Specifications
81350	Joint Army-Navy Specifications
81483	Int'l Rectifier.,El Segundo,CA 90245
81741	Chicago Lock.,Chicago,IL 60641
81831	Filtron.,Flushing,NY 11354
81840	Ledex.,Dayton,OH 45402
81860	Barry Wright.,Watertown,MA 02172
82219	Sylvania.,Emporium,PA 15834
82227	No.Amer.Philips.,Cheshire,CT 06410
82273	IN Pattern & Model.,LaPort,IN 46350
82389	Switchcraft.,Chicago,IL 60630
82567	Reeves Hoffman.,Carlisle,PA 17013
82647	Metals & Controls.,Attleboro,MA 02703
82807	Milwaukee Resistor.,Milwaukee,WI 53204
82877	Rotron.,Woodstock,NY 12498
82901	IN General Magnet.,Valparaiso,IN 46383
83003	Varo.,Garland,TX 75040
83014	Hartwell.,Placentia,CA 92670
83033	Meissner.,Mt Carmel,IL 62863
83058	Carr Fastener.,Cambridge,MA 02142
83186	Victory Eng.,Springfield,NJ 07081
83259	Parker Seal.,Culver City,CA 90231
83330	H.H.Smith.,Brooklyn,NY 11207
83361	Bearing Spclty.,San Francisco,CA
83587	Solar Elctrc.,Warren,PA 16365
83594	Burroughs.,Plainfield,NJ 07061
83740	Union Carbide.,New York,NY 10017
83766	Mass Engrs.,Quincy,MA 02171
83781	National Elctrcs.,Geneva,IL 60134
84411	TRW.,Ogallala,NB 69153
84835	Lehigh Metals.,Cambridge,MA 02140
84970	Sarkes Tarzian.,Bloomington,IN 47401
84971	TA Mfg.,Los Angeles,CA 90039
86604	Kepco.,Flushing,NY 11352
86420	Payson Casters.,Gurnee,IL 60031
86577	Prec Metal Prod.,Stoneham,MA 02180
86684	RCA.,Harrison,NJ 07029
86687	REC.,New Rochelle,NY 10801
86800	Cont Elctrcs.,Brooklyn,NY 11222
88140	Cutler Hammer.,Lincoln,IL 62656
88204	GTE Sylvania.,Ipswitch,MA 01938
88219	Gould Nat Battery.,Trenton,NJ 08607
88419	Cornell Dubilier.,Fuquay Varina,NC 27526
88627	K&G Mfr.,New York,NY
89265	Potter & Brumfield.,Princeton,IN 47671
89482	Holtzer Cabot.,Boston,MA 02119
89665	United Transformer.,Chicago,IL
89870	Berkshire Transformer.,Kent,CT 06757
90201	Mallory Cap.,Indianapolis,IN 46206
90303	Mallory Bat.,Tarrytown,NY 10591
90634	Gulton Inds.,Metuchen,NJ 08840
90750	Westinghouse.,Boston,MA 02118
90952	Hardware Prod.,Reading,PA 19602
91032	Continental Wire.,York,PA 17405
91146	Cannon.,Salem,MA 01970
91210	Gerber.,Mishawaka,IN 46544
91293	Johanson.,Boonton,NJ 07005
91417	Harris.,Melbourne,FL 32901
91506	Augat Bros.,Attleboro,MA 02703
91598	Chandler.,Wethersfield,CT 06109
91637	Dale Elctrcs.,Columbus,NE 68601
91662	Elco.,Willow Grove,PA 19090
91719	General Inst.,Dallas,TX 75220
91836	Kings Elctrcs.,Tuckahoe,NY 11223
91916	Mephisto Tool.,Hudson,NY 12534
91929	Honeywell.,Freeport,IL 61032
92519	Electra Insul.,Woodside,NY 11377
92678	Edgerton Germeshuasen.,Boston,MA 02115
92702	IMC Magnetics.,Westbury,NY 11591
92739	Ampex.,Redwood City,CA 94063
92966	Hudson Lamp.,Kearny,NJ 07032
93332	Sylvania.,Woburn,MA 01801
93346	Amer Elctrcs Labs.,Lansdale,PA 19446
93618	R&C Mfg.,Ramsey,PA 16671
93916	Cramer.,New York,NY 10013
94144	Raytheon.,Quincy,MA 02169
94154	Wagner Elctrc.,Livingston,NJ 07039
94271	Weston.,Archibald,PA 18403
94322	Tel Labs.,Manchester,NH 03102
94589	Dickson.,Chicago,IL 60619
94696	Magnecraft.,Chicago,IL 60630
94800	Atlas Ind.,Brookline,NH 03033
95076	Garde.,Cumberland,RI 02864
95121	Quality Comp.,St Marys,PA 15857
95146	Alco Elctrcs.,Lawrence,MA 01843
95238	Continental Conn.,Woodside,NY 11377
95275	Vitramon.,Bridgeport,CT 06601
95348	Gordos.,Bloomfield,NJ 07003
95354	Methode.,Rolling Meadow,IL 60008
95794	Amer Brass.,Torrington,CT 06790
95987	Weckesser.,Chicago,IL 60646
96095	Aerovox Hi Q.,Olean,NY 14760
96341	Microwave Assoc.,Burlington,MA 01801
96906	Military Standards
97918	Linemaster Switch.,Woodstock,CT 06281
98291	Sealectro.,Mamaroneck,NY 10544
98474	Compar.,Burlingame,CA 94010
98821	North Hills.,Glen Cove,NY 11542
99017	Protective Closures.,Buffalo,NY 14207
99117	Metavac.,Flushing,NY 11358
99313	Varian.,Palo Alto,CA 94303
99378	Atlee.,Winchester,MA 01890
99800	Delevan;E.Aurora,NY 14052
99934	Renbrandt.,Boston,MA 02118
99942	Centralab.,Milwaukee,WI 53201

JANUARY 1978

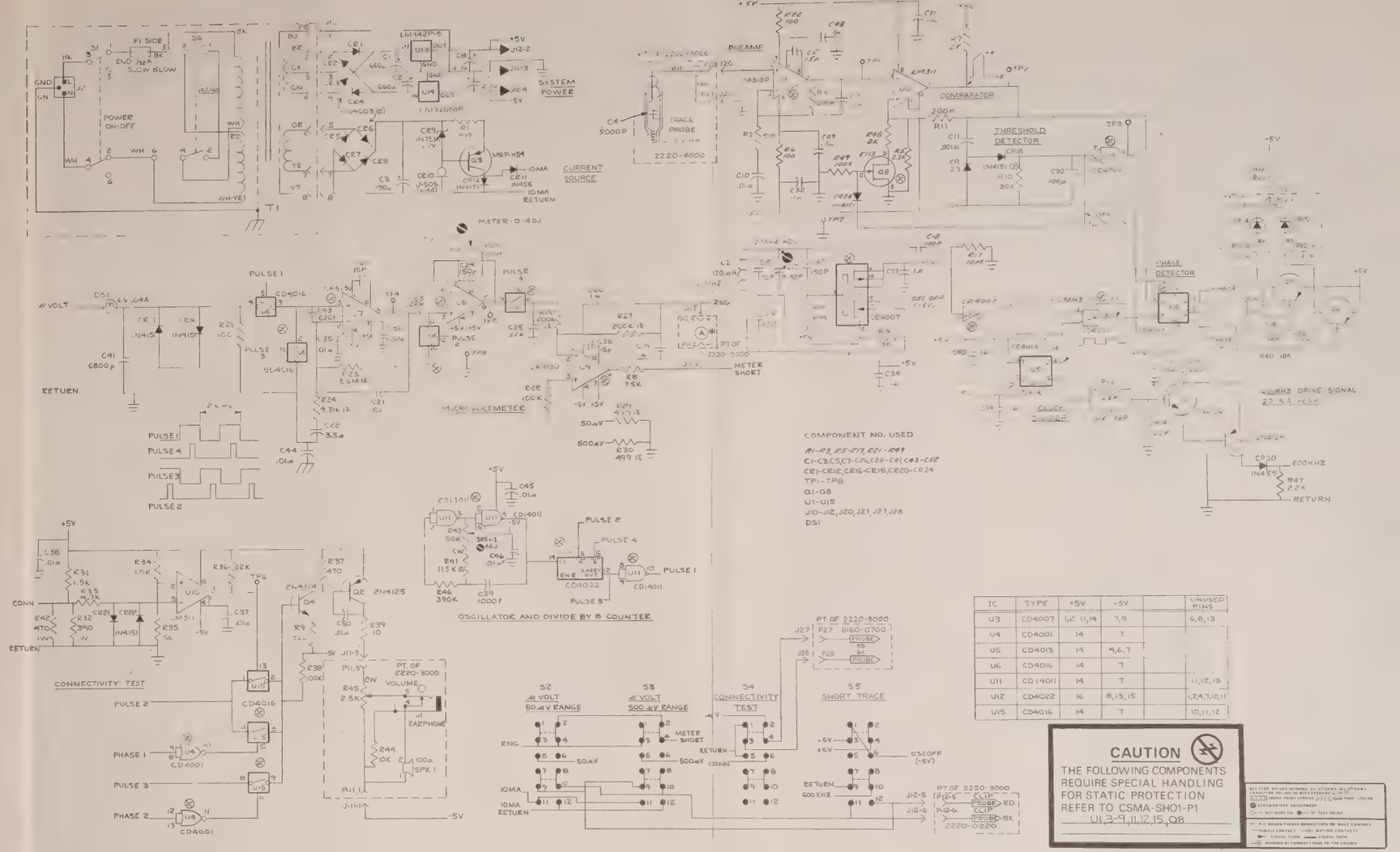
ELECTRICAL PARTS LIST

BUG HOUND CHASSIS ASM P/N 2220-3000

REFDES		DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
F	1	FUSE SLO-BLOW 1/10A 250V	5330-0400	75915	313 .100
J	1	MINATURE PHONE 2 CKT SW	4260-1110	82389	TR-2A
J	2	RECEPTACLE POWER UL STD 15A250V	4240-0250	82389	EAC-302
M	1	METER	5730-1445	24655	5730-1445
P	1	EAR PHONE	1935-0409	31487	EXT RANGE 4660-56
P	2	CORD 3WR 6A 240V IEC 7FT HMR-FEM	4200-0220	24655	4200-0220
P	11	CONNECTOR MULT PLUG 5 CIRCUITS	4220-4454	24655	4220-4454
R	44	RES COMP 10 K 5PCT 1/4W	6099-3105	81349	RCR07G103J
R	45	POT COMP KNOB 2.5K OHM 10PCT LIN	6041-2259	01121	WA1G040S252UA
S	1	SWITCH TOG MIN 2POS DPDT STEADY	7910-0812	95146	MTA-206N
S	6	SWITCH SLIDE 2 POS DPDT STEADY	7910-0832	82389	11A-1266
SP	1	SPEAKER	8000-0070	74199	2A05Z100
T	1	TRANSFORMER ASM	2220-2000	24655	2220-2000

TRACE PROBE CABLE ASM P/N 2220-4000

REFDES		DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
C	4	CAP MYLAR .009UF 5 PCT 100V	4860-7510	56289	410P .009 UF 5PCT
CR	14	LED RED	6084-1105	28480	5082-4494
CR	15	LED RED	6084-1105	28480	5082-4494
L	1	CHOKE MOLDED 8.2 UH 10PCT	4300-7558	72259	DD-8.2
P	12	CONNECTOR MULT PLUG 9 CIRCUITS	4220-4620	24655	4220-4620



COMPONENT NO. USED

R1-R3, R5-R19, R21-R49
C1-C3, C5, C7-C26, C26-C41, C63-C52
CR1-CR12, CR16-CR18, CR20-CR24
TP1-TP8
Q1-Q8
U1-U15
J10-J12, J20, J21, J27, J28
DS1

IC	TYPE	+5V	-5V		UNUSED PINS
U3	CD4007	1,2 11,14	7,9		6,8,13
U4	CD4001	14	7		
U5	CD4013	14	4,6,7		
U6	CD4016	14	7		
U11	CD14011	14	7		11,12,13
U12	CD4022	16	8,13,15		1,2,4,7,10,11
U15	CD4016	14	7		10,11,12

Figure 6-2. Bug Hound schematic diagram.

ELECTRICAL PARTS LIST

CURRENT TRACING PROBE PC BOARD P/N 2220-4700

REFDES		DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
C	1	CAP ALUM 660 UF 25V	4450-6125	56289	30D667G025
C	2	CAP ALUM 660 UF 25V	4450-6125	56289	30D667G025
C	3	CAP ALUM 150 UF 50V	4450-6050	56289	30D157G050
C	5	CAP CER .1 SQ 15PF 5PCT 100V	4400-6481	72982	8101A100Y5F150J
C	7	CAP CER .1 SQ 10PF 5PCT 100V	4400-6443	72982	8121A200X5F0100J
C	8	CAP TANT 4.7 UF 20PCT 10V	4450-4700	56289	150D475X0010A2
C	9	CAP TANT 4.7 UF 20PCT 10V	4450-4700	56289	150D475X0010A2
C	10	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	11	CAP CER DISC 1000PF 5PCT 500V	4405-2105	72982	0801082Z5D00102J
C	12	CAP CER .1 SQ 82PF 5PCT 100V	4400-6489	72982	8101-A100-Y5F-820J
C	13	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	15	CAP MICA 130 PF 5PCT 500V	4700-0439	81349	CM05FD131JN
C	16	CAP MICA 470 PF 5PCT 500V	4700-0601	81349	CM05FD471JN
C	17	CAP CER TRIM 9-50 PF N750	4910-2060	72982	3192-000 E 9-50PF
C	18	CAP CER .1SQ 100 PF 5PCT 100V	4400-6442	72982	8101A100Y5F101J
C	19	CAP CER MONO 1UF 20PCT 50VGP	4400-2070	72982	8131-M050-651-105M
C	20	CAP CER .1 SQ 15PF 5PCT 100V	4400-6481	72982	8101A100Y5F150J
C	21	CAP CER .1 SQ 10PF 5PCT 100V	4400-6443	72982	8121A200X5F0100J
C	22	CAP CER MONO 3.3UF 20PCT 50VGP	4400-2082	72982	8151-M050-651-335M
C	23	CAP CER MONO 0.22UF 20PCT 50VGP	4400-2052	72982	8131-M050-651-224M
C	24	CAP CER .1SQ 150 PF 5PCT 100V	4400-6491	72982	8101A100Y5F151J
C	25	CAP CER MONO 0.22UF 20PCT 50VGP	4400-2052	72982	8131-M050-651-224M
C	26	CAP CER MONO 1UF 20PCT 50VGP	4400-2070	72982	8131-M050-651-105M
C	28	CAP CER .1 SQ 15PF 5PCT 100V	4400-6481	72982	8101A100Y5F150J
C	29	CAP CER DISC 1000PF 5PCT 500V	4405-2105	72982	0801082Z5D00102J
C	30	CAP CER .1SQ 100 PF 5PCT 100V	4400-6442	72982	8101A100Y5F101J
C	31	CAP CER MONO 0.1UF 20PCT 50VGP	4400-2050	72982	8131-M050-651-104M
C	32	CAP CER MONO 0.1UF 20PCT 50VGP	4400-2050	72982	8131-M050-651-104M
C	33	CAP CER MONO 0.1UF 20PCT 50VGP	4400-2050	72982	8131-M050-651-104M
C	34	CAP CER MONO 0.1UF 20PCT 50VGP	4400-2050	72982	8131-M050-651-104M
C	35	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	36	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	37	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	38	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	39	CAP CER MONO 0.1UF 20PCT 50VGP	4400-2050	72982	8131-M050-651-104M
C	40	CAP CER MONO 0.1UF 20PCT 50VGP	4400-2050	72982	8131-M050-651-104M
C	41	CAP CER MONO .0068UF 10PCT 50V	4400-6355	72982	8121-M050-W5R-682K
C	43	CAP CER DISC 620PF 5PCT 500V	4404-1625	72982	0831082Z5F00621J
C	44	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	45	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	46	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	47	CAP CER .1SQ 150 PF 5PCT 100V	4400-6491	72982	8101A100Y5F151J
C	48	CAP CER MONO 0.1UF 20PCT 50VGP	4400-2050	72982	8131-M050-651-104M
C	49	CAP CER MONO 0.1UF 20PCT 50VGP	4400-2050	72982	8131-M050-651-104M
C	50	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	51	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
C	52	CAP CER DISC .01UF 80/20PCT 100V	4401-3100	72982	0805540Z5U00103Z
CR	1	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR	2	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR	3	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR	4	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR	5	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR	6	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR	7	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR	8	DIODE RECTIFIER 1N4003	6081-1001	14433	1N4003
CR	9	ZENER 1N753A 6.2V 5PCT .4W	6083-1006	14433	1N753A
CR	10	TRANS J-505 CS 1MA TO-92	8215-0104	17856	J-505
CR	11	DIODE 1N455 30PIV IR 30UA GE	6082-1010	14433	1N455
CR	12	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
CR	16	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
CR	17	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
CR	18	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
CR	20	DIODE 1N455 30PIV IR 30UA GE	6082-1010	14433	1N455
CR	21	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
CR	22	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
CR	23	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
CR	24	DIODE 1N4151 75PIV IR.1UA SI	6082-1001	14433	1N3604
DS	1	LAMP BI-PIN BASE 6V .04A 10000H	5600-1200	71744	CM7-7945
J	10	CONNECTOR WAFER 9 CIRCUITS	4230-4611	24655	4230-4611
J	11	CONNECTOR WAFER 5 CIRCUITS	4230-4610	24655	4230-4610
J	12	CONNECTOR WAFER 9 CIRCUITS	4230-4611	24655	4230-4611
J	27	TERMINAL PUSH-ON .187 BLADE PC	7920-0160	00779	61907-1
J	28	TERMINAL PUSH-ON .187 BLADE PC	7920-0160	00779	61907-1
L	2	CHOKE SHIELDED 120 UH 10PCT	4300-6366	24759	AA-5-28 120UH 10PCT
Q	1	TRANSISTOR 2N4125	8210-1125	04713	2N4125
Q	2	TRANSISTOR 2N4125	8210-1125	04713	2N4125
Q	3	TRANSISTOR MPS-H54	8210-1273	04713	MPS-H54

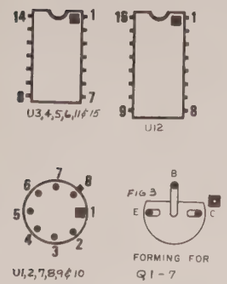
ELECTRICAL PARTS LIST (cont)

CURRENT TRACING PROBE PC BOARD P/N 2220-4700

REFDES		DESCRIPTION	PART NO.	FMC	MFGR PART NUMBER
Q	4	TRANSISTOR 2N4124	8210-1154	04713	2N4124
Q	5	TRANSISTOR 2N4125	8210-1125	04713	2N4125
Q	6	TRANSISTOR 2N4125	8210-1125	04713	2N4125
Q	7	TRANSISTOR 2N4124	8210-1154	04713	2N4124
Q	8	TRANSISTOR(STATIC PROTECT REQ)	8210-1229	17856	E-113
R	1	RES COMP 510 OHM 5PCT 1/4W	6099-1515	81349	RCR07G511J
R	2	RES COMP 510 OHM 5PCT 1/4W	6099-1515	81349	RCR07G511J
R	3	RES COMP 200 K OHM 5PCT 1/4W	6099-4205	81349	RCR07G204J
R	5	RES COMP 2.2 K 5PCT 1/4W	6099-2225	81349	RCR07G222J
R	6	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R	7	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R	8	RES COMP 7.5 K OHM 5PCT 1/4W	6099-2755	81349	RCR07G752J
R	9	RES COMP 820 OHM 5PCT 1/4W	6099-1825	81349	RCR07G821J
R	10	RES COMP 30 K OHM 5PCT 1/4W	6099-3305	81349	RCR07G303J
R	11	RES COMP 200 K OHM 5PCT 1/4W	6099-4205	81349	RCR07G204J
R	12	RES COMP 820 OHM 5PCT 1/4W	6099-1825	81349	RCR07G821J
R	13	RES COMP 22 K 5PCT 1/4W	6099-3225	81349	RCR07G223J
R	14	RES COMP 22 K 5PCT 1/4W	6099-3225	81349	RCR07G223J
R	15	RES COMP 220 OHM 5PCT 1/4W	6099-1225	81349	RCR07G221J
R	16	RES COMP 18 K 5PCT 1/4W	6099-3185	81349	RCR07G183J
R	17	RES COMP 10 M 5PCT 1/4W	6099-6105	81349	RCR07G106J
R	18	RES COMP 10 M 5PCT 1/4W	6099-6105	81349	RCR07G106J
R	19	RES COMP 3.0 K OHM 5PCT 1/4W	6099-2305	81349	RCR07G302J
R	21	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R	22	RES COMP 100 OHM 5PCT 1/4W	6099-1105	81349	RCR07G101J
R	23	RES FLM 5.62M 1 PCT 1/8W	6250-4562	81349	RN55D5624F
R	24	RES FLM 9.31 K 1 PCT 1/8W	6250-1931	81349	RN55D9311F
R	25	POT CERM TRM 100K OHM 10 PCT 15T	6049-0192	80294	3006P-1-104
R	26	RES FLM 200K 1 PCT 1/8W	6250-3200	81349	RN55D2003F
R	27	RES FLM 200K 1 PCT 1/8W	6250-3200	81349	RN55D2003F
R	28	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	29	RES FLM 49.9 OHM 1 PCT 1/8W	6250-9499	81349	RN55D49R9F
R	30	RES FLM 499 OHM 1 PCT 1/8W	6250-0499	81349	RN55D4990F
R	31	RES COMP 1.5 K 5PCT 1/4W	6099-2155	81349	RCR07G152J
R	32	RES COMP 390 OHM 5PCT 1W	6110-1395	81349	RCR32G391J
R	33	RES COMP 4.7 K 5PCT 1/4W	6099-2475	81349	RCR07G472J
R	34	RES COMP 1.5 K 5PCT 1/4W	6099-2155	81349	RCR07G152J
R	35	RES COMP 56 OHM 5PCT 1/4W	6099-0565	81349	RCR07G560J
R	36	RES COMP 22 K 5PCT 1/4W	6099-3225	81349	RCR07G223J
R	37	RES COMP 470 OHM 5PCT 1/4W	6099-1475	81349	RCR07G471J
R	38	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
R	39	RES COMP 10 OHM 5PCT 1/4W	6099-0105	81349	RCR07G100J
R	40	RES COMP 18 K 5PCT 1/4W	6099-3185	81349	RCR07G183J
R	41	RES FLM 115K 1 PCT 1/8W	6250-3115	81349	RN55D1153F
R	42	RES COMP 470 OHM 5PCT 1W	6110-1475	81349	RCR32G471J
R	43	POT CERM TRM 50K OHM 20 PCT 1T	6049-0320	80294	3386S-1-503
R	46	RES COMP 390 K 5PCT 1/4W	6099-4395	81349	RCR07G394J
R	47	RES COMP 2.2 K 5PCT 1/4W	6099-2225	81349	RCR07G222J
R	48	RES COMP 2.0 K OHM 5PCT 1/4W	6099-2205	81349	RCR07G202J
R	49	RES COMP 100 K 5PCT 1/4W	6099-4105	81349	RCR07G104J
S	2	SWITCH PUSHBUTTON MULT 4 SECT	7880-2038	24655	7880-2038
S	3	SWITCH PUSHBUTTON MULT 4 SECT	7880-2038	24655	7880-2038
S	4	SWITCH PUSHBUTTON MULT 4 SECT	7880-2038	24655	7880-2038
S	5	SWITCH PUSHBUTTON MULT 4 SECT	7880-2038	24655	7880-2038
TP	1	TERMINAL PC TEST PT	7970-2600	24655	7970-2600
TP	2	TERMINAL PC TEST PT	7970-2600	24655	7970-2600
TP	3	TERMINAL PC TEST PT	7970-2600	24655	7970-2600
TP	4	TERMINAL PC TEST PT	7970-2600	24655	7970-2600
TP	5	TERMINAL PC TEST PT	7970-2600	24655	7970-2600
TP	6	TERMINAL PC TEST PT	7970-2600	24655	7970-2600
TP	7	TERMINAL PC TEST PT	7970-2600	24655	7970-2600
TP	8	TERMINAL PC TEST PT	7970-2600	24655	7970-2600
U	1	ICL (STATIC PROTECT REQ)	5432-7000	86684	CA3130T
U	2	IC LINEAR LM311	5432-1023	10204	LM311H
U	3	ICD (STATIC PROTECT REQ)	5431-7012	86684	CD4007AE
U	4	ICD (STATIC PROTECT REQ)	5431-7004	86684	CD4001AE
U	5	ICD (STATIC PROTECT REQ)	5431-7014	86684	CD4013AE
U	6	ICD (STATIC PROTECT REQ)	5431-7061	04713	MC14016BCP
U	7	ICL (STATIC PROTECT REQ)	5432-7000	86684	CA3130T
U	8	ICL (STATIC PROTECT REQ)	5432-7000	86684	CA3130T
U	9	ICL (STATIC PROTECT REQ)	5432-7000	86684	CA3130T
U	10	IC LINEAR LM311	5432-1023	10204	LM311H
U	11	ICD (STATIC PROTECT REQ)	5431-7034	86684	CD4011AE
U	12	ICD (STATIC PROTECT REQ)	5431-7024	86684	CD4022AE
U	13	IC LINEAR LM342P-5	5432-1058	12040	LM342P-5
U	14	ICL LM320MP-5.0VOLT 3TERM REG	5432-1061	12040	LM320MP-5.0
U	15	ICD (STATIC PROTECT REQ)	5431-7061	04713	MC14016BCP

BASE DIAGRAMS

(BOTTOM VIEW)



NOTE: *Orientation:* Viewed from parts side. *Part number:* Refer to caption. *Symbolism:* Outlined area = part; gray ckt pattern = parts side, black (if any) = other side. *Pins:* Square pad in ckt pattern = collector, I-C pin 1, cathode (of diode), or + end (of capacitor).

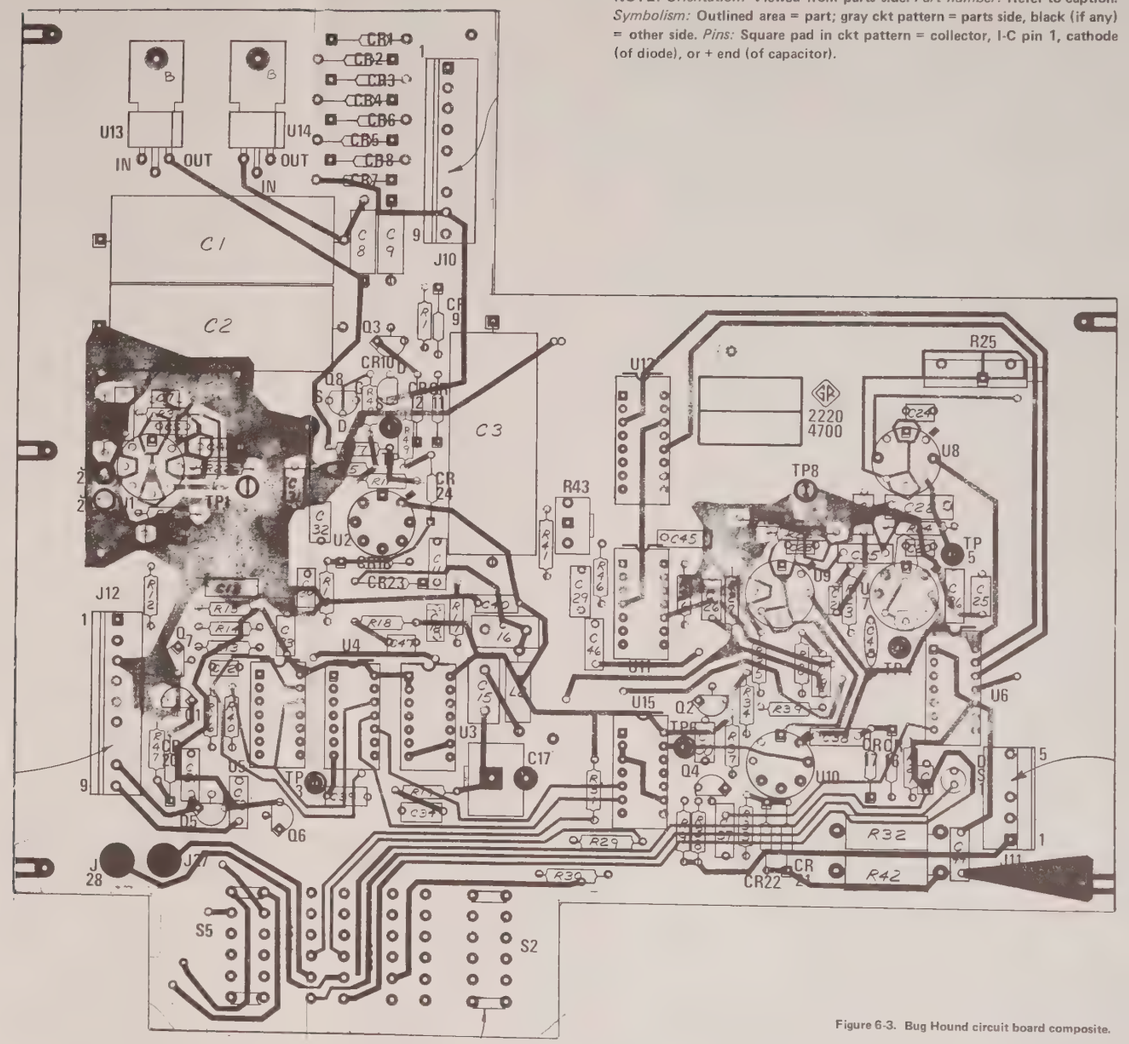


Figure 6-3. Bug Hound circuit board composite.

GenRad

300 Baker Avenue
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